KEENE

Mechanics of the Household

Mechanical Engineering

M. E.

1912

MECHANICS OF THE HOUSEHOLD

BY

EDWARD SPENCER KEENE

B. S. UNIVERSITY OF ILLINOIS, 1890

THESIS

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE

DEGREE OF

MECHANICAL ENGINEER

IN

MECHANICAL ENGINEERING

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1912

MECHANICS OF THE HOUSEHOLD

BY

EDWARD SPENCER KEENE

B. S. UNIVERSITY OF ILLINOIS, 1890

THESIS

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE

DEGREE OF

MECHANICAL ENGINEER

IN

MECHANICAL ENGINEERING

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1912

UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

April 10,1912. 190

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Edward Spencer Keene,

ENTITLED Mechanics of the Household

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Mechanical Engineer

C. R. Richards
In Charge of Major Work

C. R. Richards
Head of Department

Recommendation concurred in:

Edward C. Schmidt
G. A. Goodenough

Committee
on
Final Examination

MECHANICS of the HOUSEHOLD

A supplementary course of Physics dealing with household appliances

PART I

E. S. KEENE

Dean, Department of Engineering and Physics
North Dakota Agricultural College
Agricultural College
North Dakota

CONTENTS

CHAPTER I

The Steam Heating Plant

The use of steam as a means of heating dwellings is common in every part of the civilized world. Plants of all sizes are constructed, that not only give satisfactory service but are efficient in the use of fuel, and require the minimum amount of attention.

The manufacture of steam heating apparatus has come to be a distinct industry, and represents a special branch of engineering. Many manufacturing companies, pursue this line of business exclusively. The result has been the development of many distinctive features and systems of steam heating, that are very excellent for the purposes intended.

Practice has shown that large plants can be operated more economically than small ones. Steam may be carried through underground, insulated pipes to great distances with but small loss of heat. This has lead to the sale of exhaust steam, from the engines of manufacturing plants, for heating purposes and the establishment of community heating plants, where the dwellings of a neighborhood are heated from a central heating plant; each subscriber paying for his heat according to the number of square feet of radiating surface his house contains.

In the practice most commonly followed, with small steam heating plants, the steam is generated in a boiler located at any convenient place, but commonly in the basement. The steam is distributed through insulated pipes to the rooms, where it gives up its heat to cast-iron radiators, and from them it is imparted to the air; partly by radiation but most of the heat is transmitted to the air in direct contact with the radiator surface.

The heating capacity of a radiator is determined by its outside surface area, and is commonly termed, *radiating surface* or *heating surface.* Radiators of different styles and sizes are listed by manufacturers, according to the amount of heating surface each possesses. Radiators are sold at a definate amount per square foot, and may be made to contain any amount of heating surface, for different heights from 12 to 45 inches.

The temperature of the steam is comparatively an unimportant factor in the amount of heat given up by the radiator. It is the heat liberated at the time the steam changes from vapor to water that produces the greatest effect in changing the temperature of the house. This evolution of heat by condensatoin is due to the Latent Heat of Vaporization. It is the heat that was used up in changing the water to vapor. The following table of the properties of steam shows the temperatures and exact amounts of latent heat that correspond to various pressures.

GAUGE PRESSURE	TEMPERATURE	LATENT HEAT
0	212.0	965.7
1	215	964
2	219	961
3	222	959
4	224	957
5	227.1	955.1
6	230	953
7	232	952
8	235	950
9	237	948
10	239.4	946.4

When water at the boiling point is turned into steam at the same temperature, there are required 965.6 British Thermal Units for each pound of water changed into steam. In the table, this is the latent heat of the vapor of water at 0, gauge pressure. As the pressure, and corresponding temperature rises, the latent heat becomes less. At 10 pounds gauge pressure, the temperature of the steam is practically 240 F., but the heat of vaporization is 946 thermal units. When the steam is changed back into water, as it is when condensed in the radiators, this latent heat becomes sensible and is that which heats the rooms.

THE BRITISH THERMAL UNIT is the English unit of measure of heat. It is the amount of heat required to raise the temperature of a pound of water one degree Fahrenheit. From the table it will be seen that steam at 10 pounds gauge pressure, is only 27.4 degrees hotter than it was at 0 pounds. In raising the pressure of a pound of steam from 0 to 10 pounds, the steam only gained 27.4 B. T. U. of heat. The amount of heat gained by raising the pressure to 10 pounds is small as compared with the heat it received on vaporizing. The extra fuel used up in raising the pressure is not well expended. It is customary therefore in heating plants, to use only enough pressure in the boiler to carry the steam through the system. This amount is rarely more than 10 pounds and oftener but 3 or 4 pounds pressure.

The steam enters the radiators and coming in contact with the relatively colder walls, is condensed. As condensation takes place, the latent heat of the steam becomes sensible heat and is absorbed by the radiators and then transferred to the air of the rooms.

SYSTEMS OF STEAM HEATING.

There are now recognized four general forms of steam heating: The Low Pressure System, the High Pressure System, the Exhaust Steam System and the Vacuum System of heating; each system having special advantages when used under the required conditions. The Low Pressure System is used for house heating, except in the case of very large houses. The High Pressure and Exhaust Steam Systems are used under special conditions, in factories where high steam pressure may be obtained from a supply generated for other purposes and in places where exhaust steam from steam engines may be utilized. The Vacuum System, so extensively used in the heating of large buildings or groups of buildings, where steam must be carried long distances, will be described in another chapter.

THE LOW PRESSURE GRAVITY SYSTEM, with which we are most concerned, takes it name from the conditions under which it works. The low pressure refers to the pressure of the steam in the boiler, which is generally 3 or 4 pounds; and since the water of condensation flows back to the boiler by reason of gravity, it is a gravity system.

The placing of the pipes which are to carry the steam to the radiators and return the water of condensation to the boiler may consist of one or both of two standard arrangements. They are known as the *single-pipe system* and the *two-pipe system.*

Figure 1 shows a diagram of a single-pipe system in its simplest form. In the figure the pipe marked *supply and return,* connects the boiler with the radiators. From the vertical pipe called a *riser,* the steam is taken to the radiators through branch pipes that all slope toward the riser, so that the water of condensation may readily

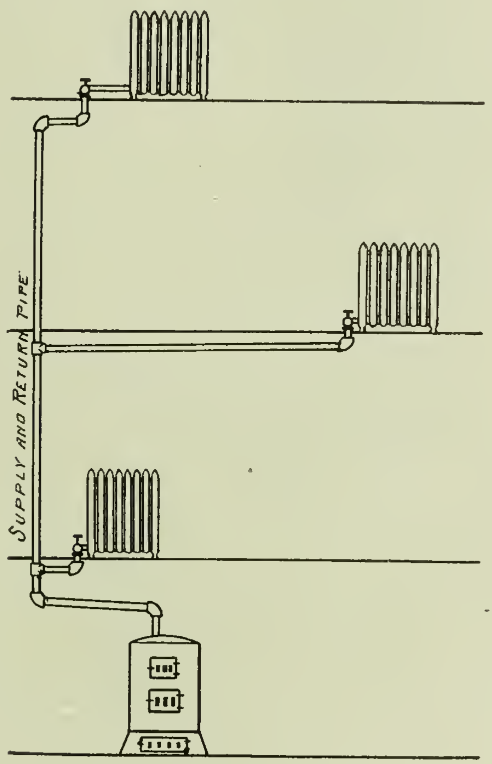


Fig. 1—Diagram of a gravity system steam heating plant.

flow back into the boiler. The water of condensation, returning to the boiler, must under this condition, flow in a direction contrary to the course of the steam supplying the radiators. In Figure 2, is given a simple application of this system. A single pipe from the top of the boiler, in the basement, marked *supply and return pipe,* connects with one radiator on the floor above. The radiator and all of the connecting pipes are set to drain the water of condensation back to the boiler.

When the valve is opened to admit steam to the radiator, the air vent must also be opened to allow the escape of the contained air. The steam will not diffuse with the air in the radiator and unless the air is allowed to escape, the steam will not enter. As the steam enters the cold radiator, it will be rapidly condensed, and will collect on the

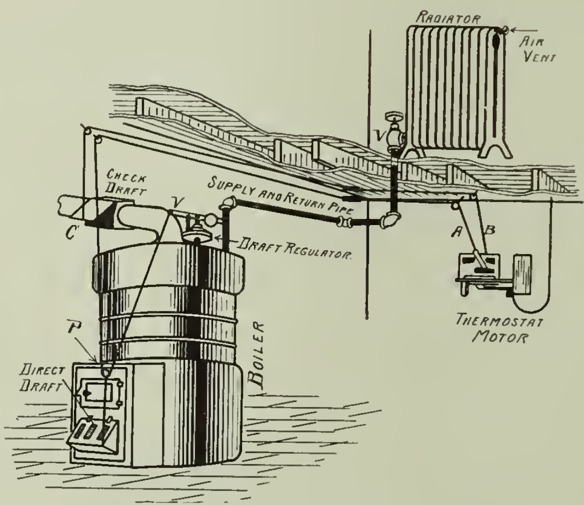


Fig. 2—A simple form of steam heating plant. The furnace fire is regulated by a thermostat and a draft regulator.

walls in the form of dew, at the same time giving up its latent heat. The heat is liberated as condensation takes place, and as the condensation takes place on the radiator walls the heat is conducted directly to the iron. The water runs to the bottom of the radiator and then through the pipes, back to the boiler. The water occupies but a little space and may return through the same pipe, while more steam is entering the radiator. As the steam condenses in the radiator, its reduction in volume tends to reduce the pressure and thus aids additional steam from the boiler to enter. In this manner a constant supply of heat enters the radiator in the form of steam which when condensed goes back to the boiler to be revaporized, at a temperature very near the boiling point. It should be kept in mind that it is the heat of vaporization, not the temperature of the steam that is utilized in the radiator, and that the heat of vaporizaion is the vehicle of transfer. The water returning to the boiler may be at the boiling point as it returns to the boiler and the steam supplying the heat to the radiators but slightly hotter.

Figure 3, is a slightly different arrangement of the same boiler as that shown in Figure 2, connected with two radiators on different floors. The same riser supplies both radiators with steam and takes the water of condensation back to the boiler.

Figure 4 is an example of the single-pipe system applied to a small house. In the drawing, the boiler in the basement is shown connected with four radiators on the first floor and three on the second floor. The pipes connecting with the more distant radiators are only extensions of the pipes connecting the radiators near the boiler. As in Figures 1, 2 and 3, all of the pipes and radiators are set to drain back into the boiler. If at any place the pipe is so graded that a part of the water is retained, poor circulation will very likely be the result, because of the restricted area of the pipe, and the radiators will not be properly heated. This lack of drainage is also a common cause of hammering and pounding in steam systems, known as *water-hammer.* The

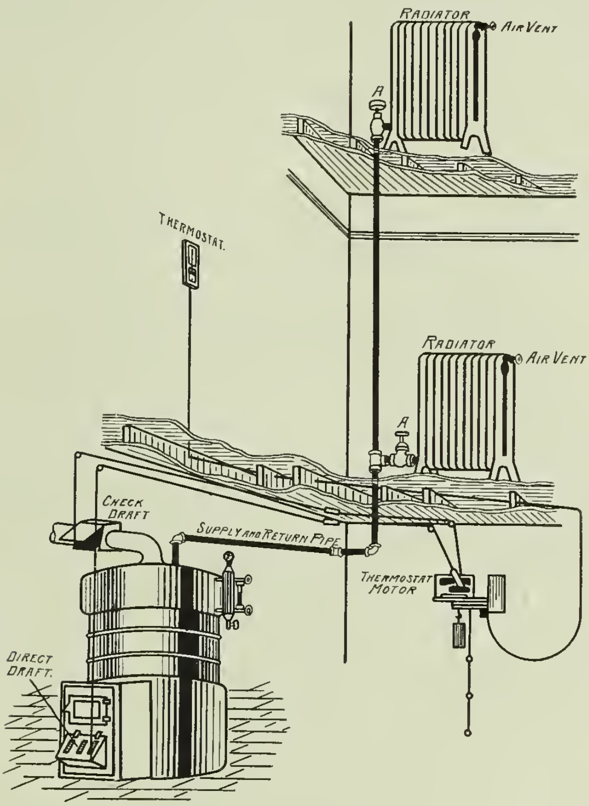


Fig. 3—A gravity system steam heating plant of two radiators. The furnace is governed by a thermostat.

formation of water-hammer is caused by steam flowing through a water-restricted area, into a cold part of the system, where condensation takes place very rapidly. The condensation of the steam is so rapid and complete that the resulting vacuum draws the trapped water into the space with the force of a hammer stroke. The hammering will continue so long as the conditions exist. The pipes in the basement are suspended from the floor joists by hangers as shown in the drawing. In practice the pipes in the basement are covered with some form of insulating material to prevent loss of heat.

As stated above, the single-pipe system may be successfully used in all house-heating plants except those of large size. It requires the least amount of pipe and labor for installation of the circulating system and when well constructed performs very satisfactorily all of the functions required in a small heating plant.

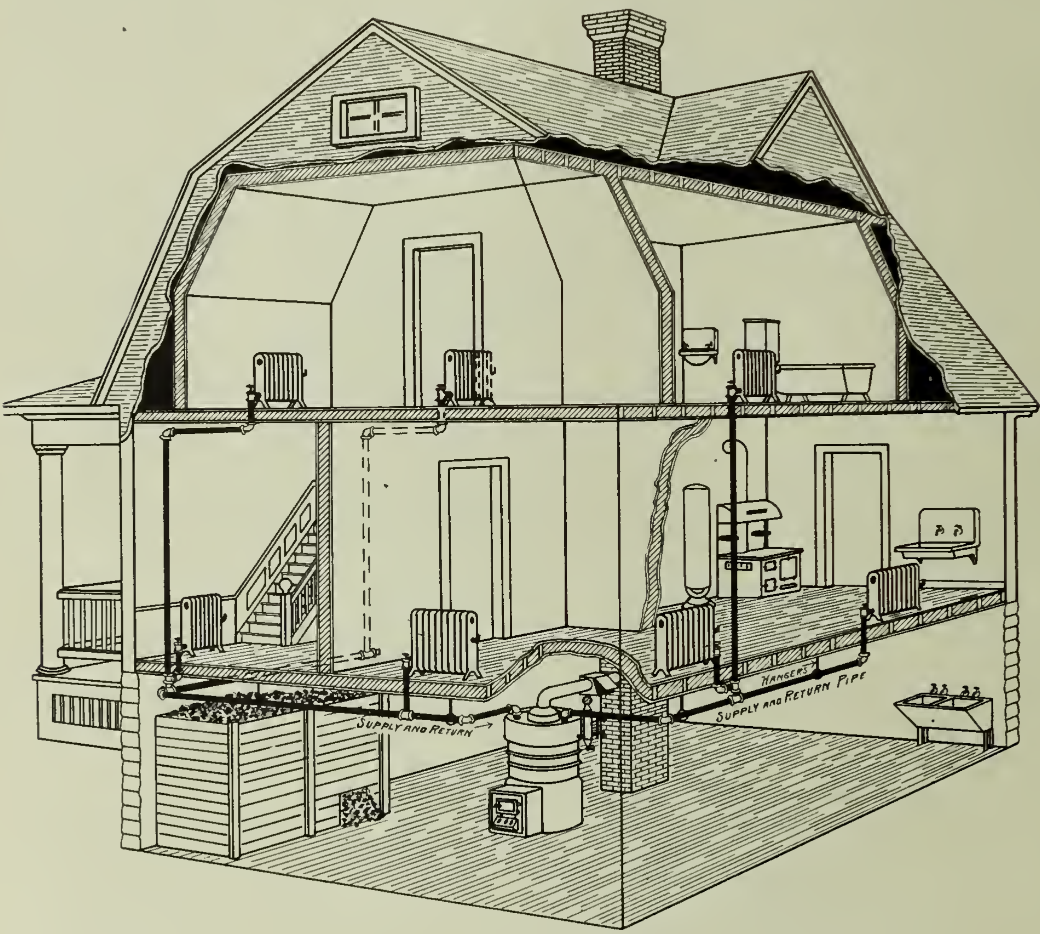


Fig. 4—The gravity system steam heating plant installed in a dwelling.

In larger buildings where greater distances require longer runs of pipe and more complicated connections, and where the volume of condensed steam is too great to be taken care of in a single pipe, this system does not always work satisfactorily. One of the commonest causes of trouble in the single-pipe system is due to the radiator connections. The steam enters and leaves the radiator through the same pipe. Water-hammer in single pipe radiators is very common and under its condition of operation is—at times—almost impossible to avoid. To remedy this condition the radiators may be arranged with one pipe to conduct steam to the radiator and a second pipe at the opposite end to carry the water of condensation back to the boiler.

TWO-PIPE SYSTEM: Figure 5. is a diagram of a two-pipe system. Here, each radiator has a *supply pipe*, through which the steam enters, and a *return pipe* which conducts the water away. The branch pipes from a common supply pipe or riser, carry steam to the various radiators and all of the return pipes empty into a single return pipe that takes the water back to its source. It will be noticed that in this case the *riser* also connects at the bottom with the return pipe. This connection is made for the purpose of conducting away the condensation that takes place in the connecting pipes. The water will always stand in these pipes, at the same height as the water in the boiler. The supply pipe from the boiler, and the branch pipes connecting the radiators all slope toward the *riser*. The condensation in the connecting pipes does not pass through the radiators as it returns to the boiler.

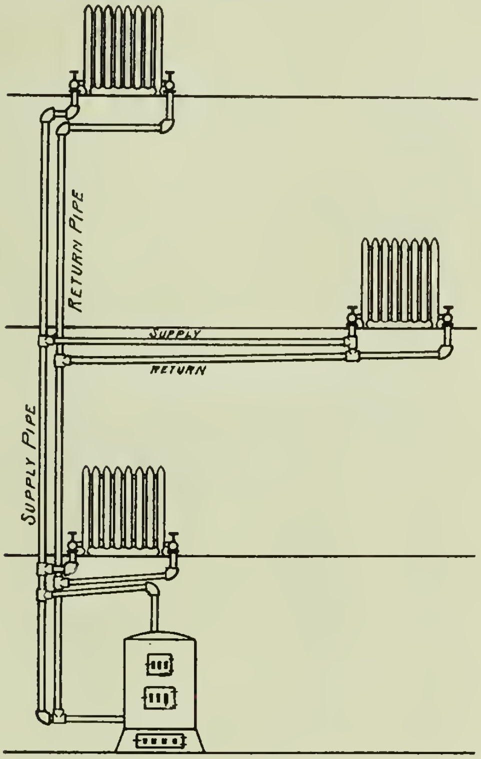


Fig. 5—Diagram showing the arrangement of a two-pipe steam plant.

An exception to this general rule is shown in the radiator on the second floor. In this case the supply pipe slopes downward as it approaches the radiator. To prevent carrying water through the radiator, a small pipe under the left-hand valve connects with the return pipe and the water is thus conducted to the main return-pipe.

Figure 6. is a simple application of the arrangement shown in Figure 5. The steam may be easily traced from the boiler to the radiators, and back through the return pipes to its source. The pipe marked R, is the connection between the main supply-pipe and the return-pipe that takes away the condensation of the riser. It is connected to the main return-pipe below the water line of the boiler and therefore does not interfere in any way with the passage of the steam. Each

radiator empties its water of condensation into a common return pipe, that finally connects with the boiler below the water-line.

This arrangement may be elaborated to almost any extent and is an improvement over the single-pipe system. It is quite commonly used as a method of steam distribution, but it lacks the required elements necessary to a positive circulation. As an example: Suppose that the plant shown in Figure 6. is working and that the radiator on the first floor is hot, but the valves of the radiator on the second floor are closed and it is cold. The steam entering at the valve A, of the lower radiator is being condensed as fast as the heat is radiated. The steam will pass on through the valve

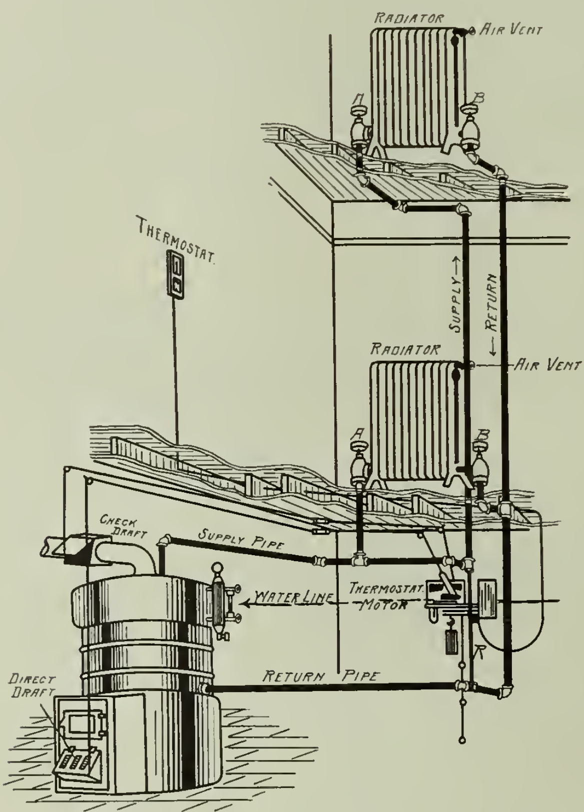


Fig. 6—An example of a two-pipe steam system.

B, into the return pipe and as soon as it becomes hot, will contain steam at practically the same pressure as that in the supply pipe. This is what takes place in every working steam plant. Now suppose that it is desired to heat the radiator on the floor above. The steam valve A, of the upper radiator is opened to admit steam and the return valve is also opened to allow the water to escape. There is steam in both the supply and return pipes of the radiator below at the same pressure, each tending to send steam into the radiator above at opposite ends. This would make a condition exactly the same as a single pipe system, with a supply pipe at both ends of the radiator and the result would, of course, be the same as in the single pipe system. There being no place for the water to escape except against the incoming steam, the water will sometimes surge back and forth with the customary noises peculiar to such conditions.

It must not be understood that this will always occur, because systems of this kind are in use with fairly good results, but noisy radiators are not at all rare when working under this condition and the cause is from that described. To overcome this difficulty and change the system into one in which there would be a positive circulation from A to B, in each radiator, allowing the steam always to enter at the valve A, and escape at B, the system must be changed to that of *separate returns*.

SEPARATE RETURN SYSTEM: A diagram of a *separate return* system is shown

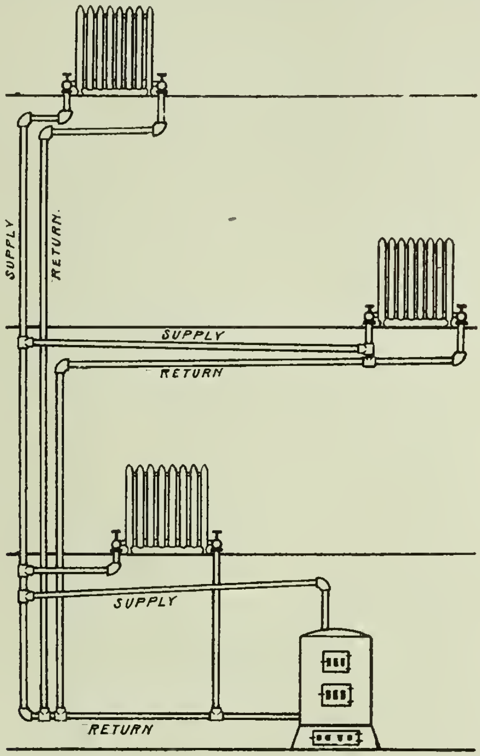


Fig. 7—Diagram of a separate return steam system.

in Figure 7. In this figure, the radiator, boiler and supply pipes are the same as those of Figure 5, but there is a separate return pipe from each of the radiators, connecting with the main return pipe at a point below the water line of the boiler. Examination of this diagram will show that there is an independent circuit for the steam through each radiator. The steam is taken from a common riser as before but after passing through the radiator the water is returned by a separate pipe to the main return pipe at the bottom of the boiler. Figure 8 is an application of *separate-return* system. It is exactly the same as Figure 6, except that each radiator has an independent return pipe. Steam must always enter the radiators at the valves A, and leave at the valves B. This makes a positive circulation that renders each radiator independent of the others. There is no opportunity for steam to pass through one radiator and interfere with the return water of another; it therefore prevents the possibility of hammering or surging so common in poorly designed steam systems.

Of all the methods of steam heating where the water of condensatoin is returned to the boiler by reason of gravity this is the most satisfactory. It requires more pipe and consequently more labor to install than the other systems described but it repays in excellence of service for the extra expense incurred.

OVERHEAD OR DROP SYSTEM: There is yet another gravity system of steam heating that is sometimes used in large buildings where economy in the use of pipe is desired; this is the *overhead* or *drop* system shown in Figure 9. It is not a common method of piping and is only given here because of its occasional use. In the arrangement of the *drop* system, the supply pipe for the radiators rises from the boiler to the highest point of the system and the branch pipes for the radiators are taken off from the descending pipe. Its action is the same as that of a single pipe system but the advantage gained by the arrangement is that the steam in the main supply pipes travels in the same direction as the returning water of condensation; the cause of *surging* in long *risers* is thus eliminated.

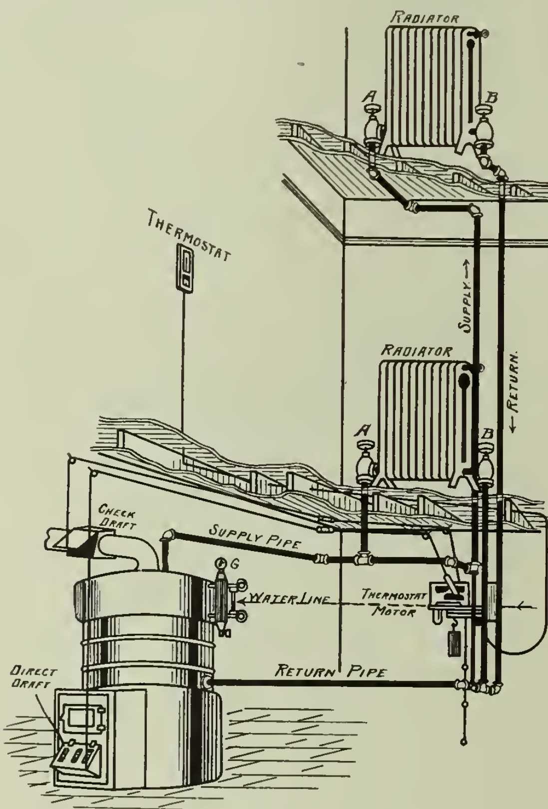


Fig. 8—A separate return steam plant.

The two-pipe systems of steam heating is more certain in action than the single pipe methods because there is nothing to interfere with the progress of the steam on its way to the radiators. In long branch pipes of the *single-pipe* system, the returning water is frequently caught by the advancing steam and carried to the end of the pipe, when *slugging* and *surging* is the result.

WATER-FILLED RADIATORS: Radiators frequently fill with water and are noisy because of the position of the valve. This may be true in any gravity system but particularly so in radiators having a single pipe. When the valve of a single-pipe radiator is opened a very small amount, the entering steam is immediately condensed but the water cannot escape because the incoming steam entirely fills the opening. Under this condition, the radiator may entirely fill with water. If the valve is then opened wide, the imprisoned water has an opportunity to escape while the steam is entering, but the entering steam and escaping water sets up a water-hammer that sometimes is terrific and lasts until the water is discharged from the radiator. The same condition may exist in a two-pipe system, if the steam valve is slightly opened while the escape valve is closed, but in a well designed system the radiator will be immediately emptied when both valves are open.

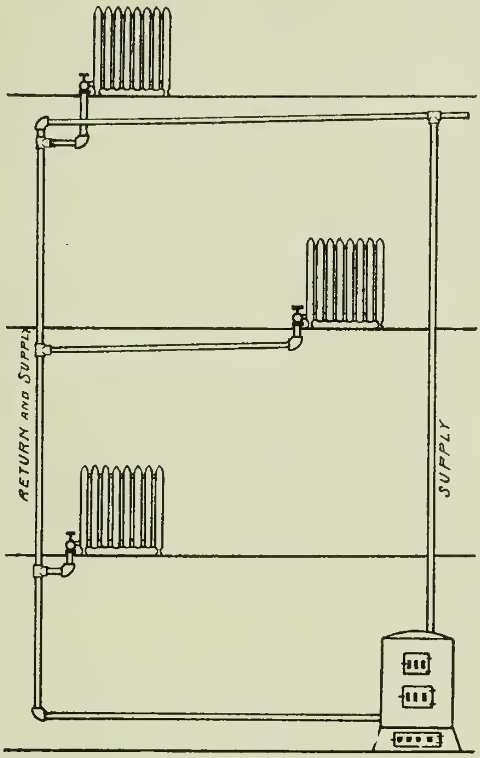


Fig. 9—Diagram of the overhead or drop system, steam plant.

AIR VENTS: All radiators must be provided with air vents. The vent is placed near the top of the top of the last loop of the radiator, at the end opposite from the entering steam, as indicated in Figures 2, 3, 6, etc. The object of the vent is to allow the air to escape from the radiator as the steam enters. Steam will not diffuse with the air and therefore cannot enter the radiator until the air is discharged. The Air Vent may be a simple cock such as is shown in Figure 10, that must be opened by hand when the steam is turned on, to allow the air to escape, and closed when the steam appears at the vent; or it may be an Automatic Vent, that opens when the radiator cools and closes automatically when the radiator is filled with steam. There are many makes of Air Vents of both hand-regulating and automatic types; of the former, figure 10, furnishes a common example. The part A, in the figure is threaded and screws tightly

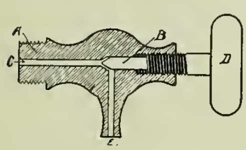


Fig. 10—A common form of air vent for radiators.

into a hole made to receive it in the end loop of the radiator. The part B, is a screw-plug that closes the passage C, leading to the inside of the radiator. When the steam is turned on, the vent must be opened until the air is discharged, after which it is closed by the hand-wheel D.

AUTOMATIC AIR VENTS: These vents depend for their action on the expansion of a part of the valve due to the temperature of the steam. The valve remains closed when hot and opens when cold. The difference in temperature between the steam and the expelled air from the radiator is the controlling factor. In the automatic vent shown in Figure 11, the part A is screwed into the radiator loop. The discharge C is open to the air or connected with a drip pipe, which returns the water to the basement. The cylinder D, which closes the passage B, is made of a material of a high coefficient of expansion. The piece D, when cool is contracted sufficiently to leave the passage B, open to the air. When the steam is turned on, the expelled air from the radiator escapes through B and C, but when the steam reaches D, the heat quickly expands the piece and closes the vent.

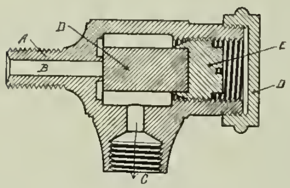


Fig. 11—An inexpensive automatic radiator air vent.

Most automatic vents require adjusting when put in place and occasionally need readjustment. The cap O, of Figure 11, may be removed with a wrench and a screw-driver used to adjust the piece D, so as to shut off the steam when the radiator is filled with steam. The expanding piece is simply screwed down until the steam ceases to escape.

Figure 12 is another style of automatic vent, constructed on the same principle as that of Figure 11, but probably more positive in action. In this vent the part A, attaches to the radiator. The expanding portion B, is made in the form of a hollow cylinder, through which the air and steam escapes to the atmosphere. It is longer than the corresponding piece in the other vent and is more sensitive because of its greater length and exposed surface. As the piece B, elongates from expansion, the upper end makes a joint with the conical piece D. The shape of this latter piece gives better opportunity for a tight joint than in the other form of vent and in practice gives better service.

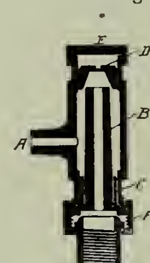


Fig. 12—Monash No. 16 automatic air vent.

Figure 13, is a cross section of the Allen vent. This is an example of a vent which depends for its action on a float. Whenever sufficient water accumulates in the body of the vent to raise the float, it closes the vent by means of its buoyancy. The body of the vent shown in Figure 13 is composed of two concentric cylinders. The float E, occupies the inner cylinder, while surrounding it is the outer cylinder D. The outer cylinder is entirely closed except a little hole at G. The float is made of light metal and fits loosely in the inner cylinder. The steam from the radiator condenses in the vent until the inner cylinder is filled with water, up to the opening A. The float by its buoyancy keeps the opening in B. stopped, and no steam can escape. The air of the outer cylinder D. is expanded by the heat of the steam and most of the air has escaped through G. When the radiator cools, the rare-

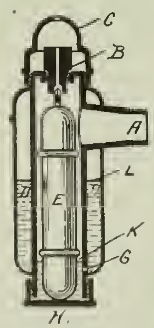


Fig. 13 — The Allen float, radiator air vent.

fied air in D contracts and draws the water from the inner cylinder into the space D; this allows the float to fall and upstop the opening in B. When the steam again reaches the vent, the heat expands the air in D, and forces the water into the inner cylinder; the float is again raised and stops the opening in B.

Many other air vents are in common use but most of them operate on one or the other of the principles described. Figure 11 is a relatively inexpensive vent, while Figure 12 is higher priced.

STEAM RADIATOR VALVES: Like most other mechanical appliances that are extensively used, radiator valves are made by a great number of manufacturers and in a great many forms. Some possess special features that are intended to increase their working efficiency but the type of radiator valve most commonly used for ordinary construction is that illustrated in Figures 14 and 15. It is a style of *angle valve* that

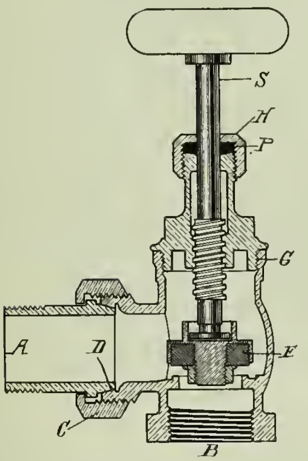


Fig. 15—Sectional view of a steam radiator valve.

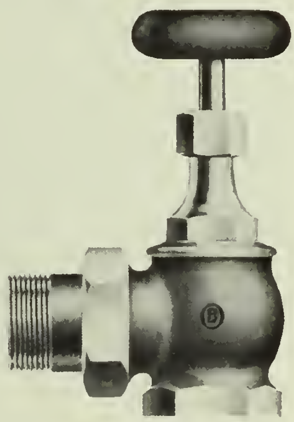


Fig. 14—Steam radiator valve.

takes the place of an elbow and being made with a *union* joint, also furnishes a means of disconnecting the radiator without disturbing the pipes. Figure 14 is an outside view of the valve and Figure 15 shows its mechanical construction. The part B screws onto the end of the steam pipe and A connects with the radiator. The part C-D is the *union*. The nut C, screws onto the valve and makes a steamtight joint at D, between the parts. In case it is desired to remove the radiator, it furnishes an easy means of detaching the valve. The composition valve-disc E, makes a seat on the brass ring directly under it, to shut off the steam. In case the valve leaks, the disc may be removed by taking the valve casing apart at G. The worn disc can then be replaced with a new one which may be obtained from the dealer who furnished the valve. The only moving part of the valve exposed to the air is at the point where the valve-stem S enters the casing. This joint is made steamtight by the packing P. The packing is greased candle wicking, that is wound around the stem and held tightly in place by the screw-cap H. If the valve leaks at this joint, a turn or two with a wrench will stop the escape of the steam.

THE BOILER.

House-heating boilers were formerly made of sheet metal and are still so constructed to some extent, but by far the greater number are now made of cast-iron. Sheet metal boilers are constructed at the factory, ready to be installed, but the cast-iron type is made in sections and assembled to make a complete boiler, at the time the plant is erected. Sectional boilers are convenient to install, on account of the possibility of handling the parts in a limited space, that would not admit an assembled boiler without tearing down a part of the basement for admission.

Cast-iron boilers as commonly used for heating dwellings are made in two definite styles. The small sizes are cylindrical in form and are used for either steam or hot-water heating. The larger sizes are made as illustrated in Figures 16 and 17.

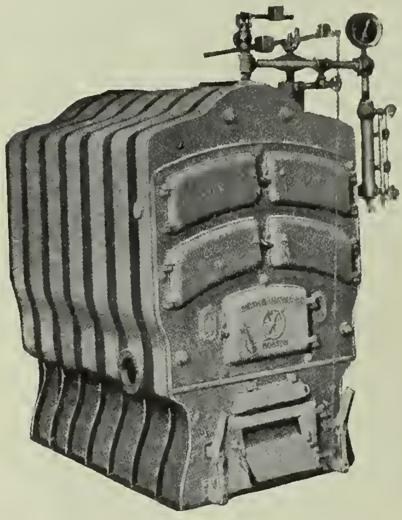


Fig. 16—Sectional cast iron boiler for steam or hot-water heating.

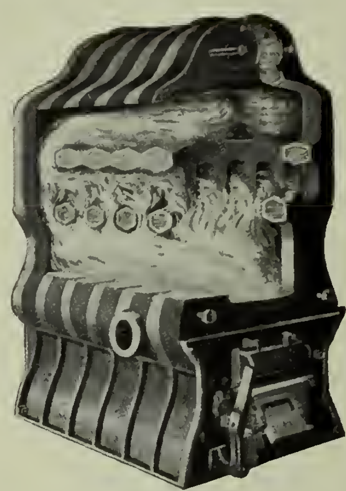


Fig. 17—Sectional view of the boiler shown in Figure 16.

The former being an outside view, and the latter showing the internal arrangement of the same boiler. The fire-box, water space and smoke passages are easily recognized. Each division represents a separate section which assembled as that in the figures makes a complete boiler with a common opening as shown at the top of Figure 17. These boilers are used for residences of large size and for buildings of less than 10,000 feet of radiating surface. For large buildings, the steam is most commonly generated in boilers built for high pressure.

In small plants, intended for either steam or hot-water heating, the cylindrical style of boiler shown in Figure 18, is commonly used. As constructed by different manufacturers, the parts differ quite materially but Figure 18. shows all of the essential features and serves to illustrate the different working parts. The sections into which the boiler is divided are indicated on the left-hand side of the figure by the numbers 1-6. The parts from 1 to 5 are screwed together with threaded nipples, joining the central column. The part 6 contains the grate and the ash-pit, with the draft and clean-out doors.

The drawing shows the boiler cut through the middle length-wise and exposes to view all of the essential features. The fire-box and the spaces occupied by the steam and water are easily recognized. It will be seen that the water-space surrounds the fire-box except at the bottom and that the space above the fire-box presents a large amount of heating surface to the flame and heated gases as they pass to the chimney. The arrows show their course; first through the openings near the center, then through

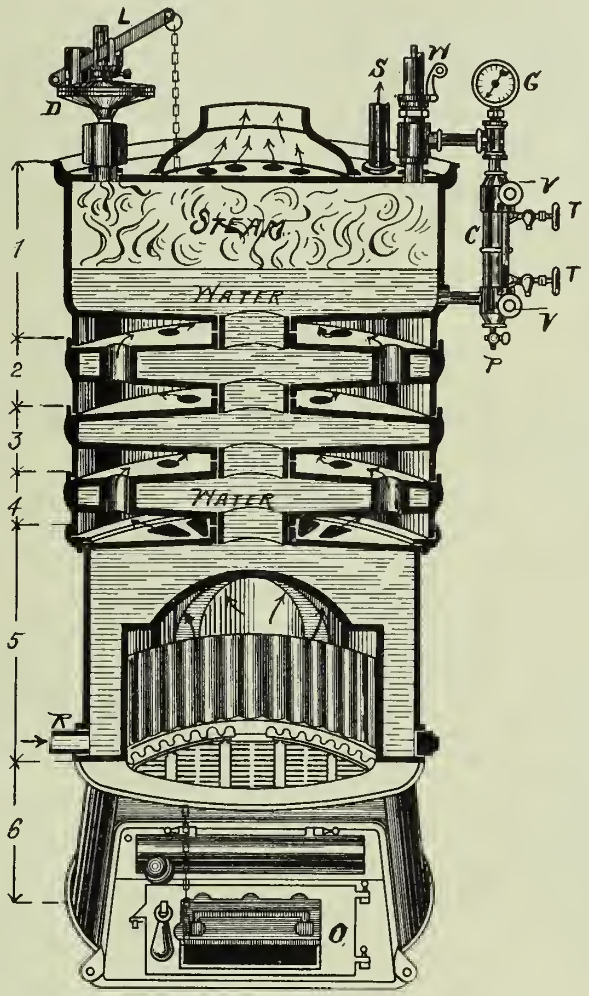


Fig. 18—Sectional view of the cylindrical type of cast-iron, sectional boiler.

those further away. The object being to keep the heat as long as possible in contact with the heating surfaces without interfering with the draft.

There is no standard method of rating the heating capacity of boilers of this kind and as a consequence, boilers of different makes—for the same rating—are not the same in actual heating capacity. The boilers are sold by their makers in sizes, that are intended to furnish heat sufficient to supply a definite number of square feet of radiating surface. The ratings are quite generally too high. A common practice with contractors, is to select boilers for a given plant 50 per cent. and even 100 per cent. larger than those rated by the manufacturers for the same amount of radiation. Some manufacturers sell their boilers at honest ratings but they are exceptions.

In specifying the capacity of a house-heating plant it is common practice to require the boiler to be of such size as will easily heat a definite number of square feet of radiating surface. The radiators are required to possess sufficient radiating surface to keep the house at 70 degrees F. in any weather. In the absence of any rules or specifications for determining the heating capacity of the boiler, the only means of securing a satisfactory plant is to require a guarantee of the contractor to install a boiler such as will fulfil the conditions stated above.

Boiler Trimmings: Attached to the boiler and required for its safe operation are a number of appliances that demand special attention. The office of each part should be thoroughly appreciated and the mechanical construction should be fully understood. An intimate acquaintance with the details of the plant, helps to make its operation satisfactory and adds to the efficiency with which it can be made to perform its duty.

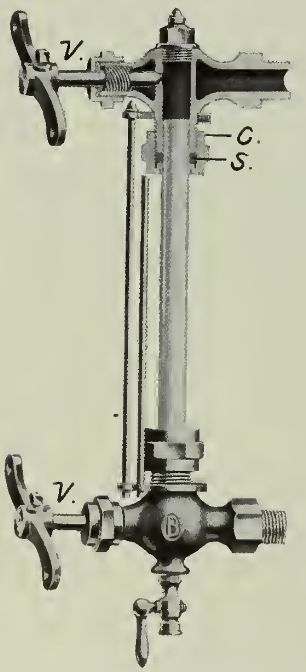


Fig. 19—The water gauge.

The Water Column: In Figure 18, the water column is shown at C. It is attached to the boiler by pipes at points above and below the water line, so as to allow a free passage of the water of the boiler to the interior. The water line should be 3 or 4 inches above the top heating surface. Attached to the water column is the *gauge-glass*, the *try-cocks*, T and T, and the *steam-gauge*, G.

The object of the gauge glass is to show the height of the water in the boiler. It is shown in place on the boiler in Figures 16 and 18 and in detail in Figure 19. The lower part of the gauge glass occupies a position on the boiler about two inches above the top heating surface. When the boiler is working, the level of the water should always be visible in the glass and should stand normally one-third to one-half full.

The water gauge is attached to the water-column by two brass valves, V. The valves are provided so that in case the water glass should be broken the openings may be closed. The ends of the glass are made tight by "stuffing-boxes" marked C, in the figure. The packing S, is generally in the form of rubber rings but greased wicking may be used if necessary as in the case of valve stems.

The Try Cocks, T and T, are also intended to indicate the height of the water in the boiler and if the water-glass should be broken may be used in its place. The openings of the try-cocks point toward the floor. When a cock is opened, should steam alone escape, it will be absorbed by the air, but if water is escaping, although much of it will be vaporized and look like steam, some of the water will be carried to the floor and produce a wet spot. The escaping water from the lower cock should always wet the floor when the cock is opened wide.

THE DRIP COCK, P at the bottom of the gauge glass is for draining the water-column and for blowing out any deposit that may collect in the opening of the column. This cock should be opened occasionally to assure the correctness of the gauge-glass.

THE STEAM GAUGE: Steam pressure is measured in pounds to the square inch above the pressure of the atmosphere. The gauges used for indicating the pressure of the steam are made in several forms but the type most commonly used is that shown in Figure 20. It is known as the Bourdon type of gauge and takes its name from the bent tube A, which furnishes its active principle. The Bourdon barometer invented in 1849 employed this form of sensitive tube. In the drawing the face of the gauge has been removed to show the working parts. The sensitive part is the flat elastic tube A, which is bent in the form of a circle. When the pressure of the steam enters at S, the air in the tube is compressed and the tube tends to straighten. The movement of the tube caused by the steam pressure is communicated to the pointer by a link connection and gear as shown in the drawing. The amount of straightening of the tube will be in proportion to the steam pressure and is indicated by the numbers marked on the face of the gauge. When the pressure is released, the tube returns to its original position and the spiral spring C, turns the hand back to its first position.

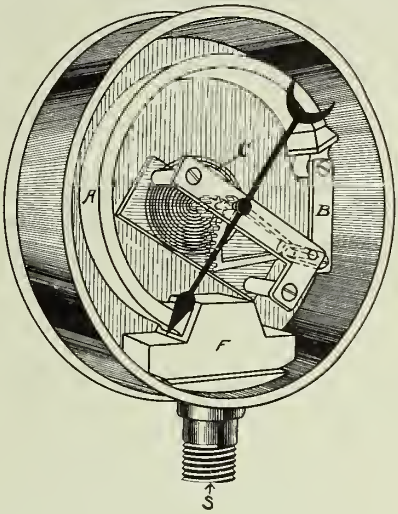


Fig. 20—The steam gauge with the front removed.

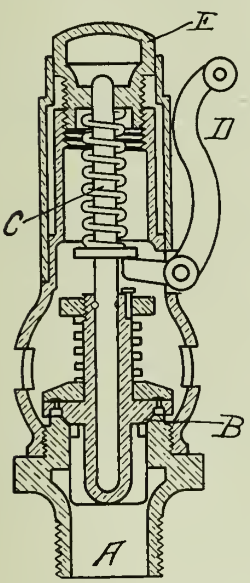


Fig. 21—Cross section of a pop valve.

THE SAFETY VALVE: All steam boilers should be provided with safety valves as a safeguard against excessive steam pressures. Of the various types of safety valves, that known as the *Pop-valve* is most commonly used on house-heating boilers. It is indicated at W, in Figure 18 and is shown in section in Figure 21. The part A, is screwed into the top of the boiler at any convenient place. The pressure of the spring C holds the valve B on its seat until the internal pressure reaches a certain intensity at which the valve is set; when it opens and allows the excess steam to escape. When the pressure is reduced the spring forces the valve back on its seat. The handle D, permits the valve to be lifted at any time as an assurance that it is in working order. This should be done occasionally, as the valve may stick to the seat after long standing and allow the pressure to rise above the point at which it should "pop."

The valve may be set to "blow off" at any desired pressure by the adjusting piece E. House-heating boilers generally have their safety-valves set to blow off at 8 or 10 pounds.

THE DRAFT REGULATOR: As a means of automatic control of the steam pressure, the draft-regulator is frequently used to so govern the fire that when a certain steam pressure is reached, the direct draft will be automatically closed and the check draft damper opened. The draft regulator is shown in place at D, in Figure 18, and will also be found in Figure 16. A detailed description of the regulator will be found on page 48.

RULE FOR PROPORTIONING RADIATORS.

Rules for determining the amount of radiating surface that will be required to satisfactorily heat a building to 70 degrees F. regardless of weather conditions are entirely empirical, that is they are derived from experience. It is evident that no definite rule can be established that will take into account the method of building construction, the kind and amount of materials that make up the walls and the quality of workmanship employed. These variable quantities coupled with the changing climatic conditions of temperature and wind velocity produce a complication that cannot be overcome in a formula that will give exact results.

Many rules are in use for this purpose, no two of which give exactly the same results when applied to a problem. A common practice is to apply one of the rules in use and then under conditions of exceptional exposure, to add to the amount thus calculated as experience may dictate.

The following rule by Professor R. G. Carpenter of Cornell University was taken from a hand-book published by the J. L. Mott Iron Works of New York. This company manufactures and deals in all kinds of apparatus entering into steam and hot-water heating and the rule is given as one that has produced satisfactory results:

Rule: Add the area of the glass surface in the room to one quarter of the exposed wall surface, and to this add from 1-55 to 3-55 of the cubical contents (1-55 for rooms on upper floor, 2-55 for rooms on first floor and 3-55 for large halls) ; then for steam multiply by .25, and for hot water by .40.

Example: A room 20×12×10 feet with glass exposure of 48 feet, ¼ of wall exposure (two sides exposed) 320 feet=80, 1-55 of 2,400=44.

48+80+44=172×.25=43 feet

If you add 2-55 the surface would be 54 feet.

If you add 3-55 the surface would be 65 feet.

PROPORTIONING THE SIZE OF MAINS.

For any size system of steam or water heating the following rule will be found entirely satisfactory for mains one hundred feet long; for each one hundred feet additional use a size larger ratio.

Rule:

$$r = \frac{3.1416}{d} \qquad R = \frac{a}{r} \times 100.$$

r, represents ratio of main in inches for each one hundred feet of surface; d, diameter of pipe; R, quantity of radiation carried by size of pipe; a, area of pipe in inches.

From this the following table has been constructed:

Diameter of Pipe	Area of Pipe	Ratio to each 100 feet of surface	Quantity of Radiation, Steam or Water, on a given size pipe
1½	1.767	2.10	84
2	3.141	1.57	200
2½	4.908	1.25	400
3	7.069	1.04	700
3½	9.621	.90	1062
4	12.566	.78	1590
4½	15.904	.70	2272
5	19.625	.63	3120
6	28.274	.52	5440
7	38.484	.45	8550
8	50.265	.40	12556
9	63.617	.35	18100
10	78.54	.30	25300

FORMS OF RADIATORS.

Radiators are much the same in appearance for both steam and hot-water heating. They are hollow cast-iron columns so designed that they may be fastened together in units of any number of sections. The sections are made in size to present a definite number of square feet of outside surface that is spoken of as radiating surface. The amount of radiating surface in any radiator depends on its height and the contour of the cross section. The radiator sections may be made in the form of a single column as Figure 22 or they may be divided into two, three, four or more columns to increase their radiating surface.

The following table taken from a manufacturer's catalogue shows the method of rating the heating capacity of a particular design. In the table, the first column gives the number of sections in the radiator, the second column states the length of the radiator in inches. The columns headed Heating Surface, give the heights of the sections in inches and the amount of radiating surface in various radiators of different heights and numbers of sections. As an example: this table refers to the three column radiators of Figure 23. Such a radiator 32 inches high with 10 sections would contain 45 square feet of radiating surface and would be 25 inches in length.

No. of Sections	Length 2½ in. per section.	Heating Surface—Square Feet: 45 in. high, 6 sq. ft. per sec.	38 in. high, 5 sq. ft. per sec.	32 in. high, 4½ sq.ft. per sec.	26 in. high, 3¾ sq.ft. per sec.	23 in. high, 3¼ sq.ft. per sec.	20 in. high, 2¾ sq.ft. per sec.
2	5	12	10	9	7½	6½	5½
3	7½	18	15	13½	11¼	9¾	8¼
4	10	24	20	18	15	13	11
5	12½	30	25	22½	18¾	16¼	13¾
6	15	36	30	27	22½	19½	16½
7	17½	42	35	31½	26¼	22¾	19¼
8	20	48	40	36	30	26	22
9	22½	54	45	40½	33¾	29¼	24¾
10	25	60	50	45	37½	32½	27½
11	27½	66	55	49½	41¼	35¾	30¼
12	30	72	60	54	45	39	33
13	32½	78	65	58½	48¾	42¼	35¾
14	35	84	70	63	52½	45½	38½
15	37½	90	75	67½	56¼	48¾	41¼
16	40	96	80	72	60	52	44
17	42½	102	85	76½	63¾	55¼	46¾
18	45	108	90	81	67½	58½	49½
19	47½	114	95	85½	71¼	61¾	52¼
20	50	120	100	90	75	65	55
21	52½	126	105	94½	78¾	68¼	57¾
22	55	132	110	99	82½	71½	60½
23	57½	138	115	103½	86¼	74¾	63¼
24	60	144	120	108	90	78	66
25	62½	150	125	112½	93¾	81¼	68¾
26	65	156	130	117	97½	84½	71½
27	67½	162	135	121½	101¼	87¾	74¼
28	70	168	140	126	105	91	77
29	72½	174	145	130½	108¾	94¼	79¾
30	75	180	150	135	112½	97½	82½
31	77½	186	155	139½	116¼	100¾	85¼
32	80	192	160	140	120	104	88

Figure 22 is a radiator made up of eight single column sections. In Figure 23 is shown five three-column radiators, varying in height from 20 inches to 45 inches.

The sections of steam radiators are joined together at the bottom with *close-nipples*, so as to leave an opening from end to end. The sections of hot-water radiators are joined in the same manner, except that there is an opening at both top and bottom. Figure 30 shows the openings of a hot-water radiator installed as *direct-indirect* heater. Figure 24 illustrates a special form of radiator that is intended to be placed under windows and in other places that will not admit the high form. Such a radiator as that shown in the picture is often covered with a window seat and in cold weather

Fig. 22—Single column radiator.

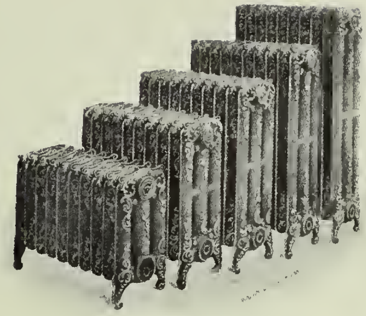


Fig. 23—Three column radiators.

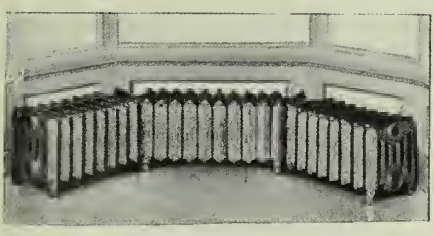


Fig. 24—Six column, low form radiator.

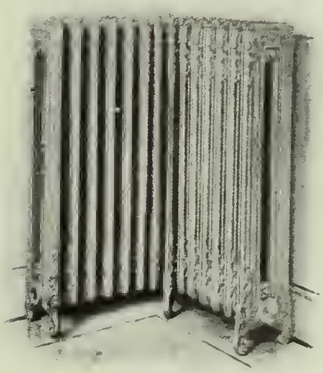


Fig. 25—Two column, corner radiator.

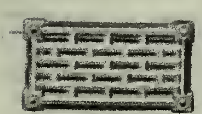


Fig. 26—Wall radiator.

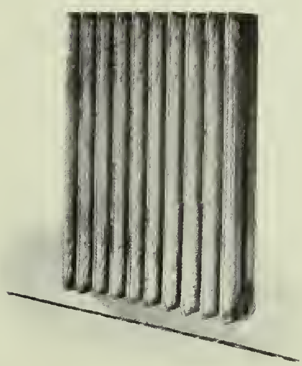


Fig. 27—Radiator suspended from the wall by brackets.

becomes the favorite place of the sitting room. Another special form is that of Figure 25. As a corner radiator this style is much to be preferred to the ordinary method of connection; here the angle is completely filled—there is no open space in the corner.

Wall radiators such as shown in Figure 26 are made to set close to the wall, where floor space is limited. They are particularly adapted for use in narrow halls, bath-rooms and other places where the ordinary type could not be conveniently used.

A radiator that will appeal to all neat housekeepers is that of Figure 27. It does not stand on the floor as in the case of the ordinary type, but is hung from the wall by concealed brackets. The difficulty of sweeping under this radiator is entirely avoided.

Fig. 28 — Radiator with a warming oven

Figure 28 is a radiator designed to furnish a warming oven for plates and for heating the room at the same time. It is sometimes installed in dining-rooms.

The ordinary method of heating by the use of radiators is known as the *direct* method. The air is heated by coming directly in contact with the radiators and distributed through the room by convection. If the arrangement is such that the air is brought from out-doors and heated by the radiators before entering the room, it is called the *indirect* method of heating. Such an arrangement is illustrated in Figure 29. The radiator is located beneath the floor, in a passage that takes the air from out-doors and after being heated, enters the room through a register located in the wall.

Figure 30 is still another arrangement known as the *direct-indirect* method of heating. The radiator is placed in position, as for direct heating, but the air supply

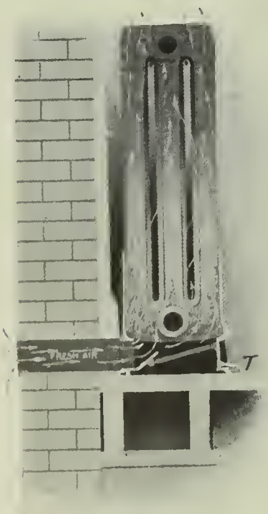


Fig. 30—Direct-indirect method of arranging radiators.

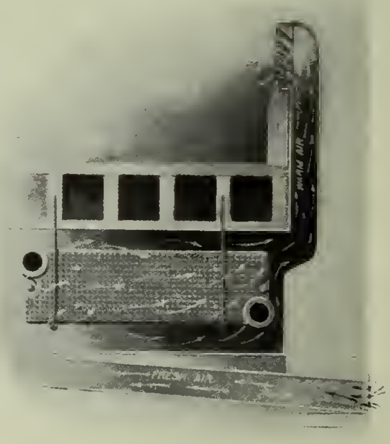


Fig. 29—Indirect system of heating by radiators.

is taken from out-doors. The radiator base is enclosed and a double damper T, regulates the amount of air that comes from the outside. When the inside damper is closed and the outside damper is open, as is shown in the drawing, the air comes from out-doors and is heated as it passes through the ardiator on its way to the room. If the dampers are reversed, the air circulates through the radiator as in the case of direct radiation.

In the use of the *direct* or the *direct-indirect* method of heating the principal object to be attained is that of ventilation, but quite generally the passages are so arranged that the air may be taken from out-doors or, if desired, the air of the house may be sent through the radiators to be reheated. In extremely cold and windy weather it is sometimes difficult to keep the house at the desired temperature when all of the air supply comes from the out-side. Under such conditions the outside air is only used occasionally. In mild weather it is common to use the out-door air most of the time. The cost of heating, when these methods are used, is higher than by direct radiation, because the air is being constantly changed in temperature from that of the outside to 70 degrees.

PIPE COVERINGS.

All hot-water or steam pipes in the basement and in other places not intended to be used for heating should be covered with some form of insulating material. At ordinary working temperature a square foot of hot pipe-surface will radiate about 15 British Thermal Units of heat per minute. To prevent this loss of heat and the consequent waste of fuel the pipes should be covered with some form of insulating material.

Pipe coverings are made of many kinds of materials and some possess insulating properties that may reduce the loss to as low a point as 15 per cent of the amount radiated by a bare pipe. Many good insulating materials do not give satisfactory results as pipe coverings because they do not keep their shape, some cannot be considered in the average plant because of high cost.

Wood-pulp paper is extensively used as a cheap covering; it is a good insulator and under ordinary condtiions makes a satisfactory covering. A more efficient and also a more expensive covering that is extensively used, is that made of Magnesia Carbonate and known as Magnesia Covering. Aside from these, other forms made of cork, hair-felt, asbestos and composition coverings are sometimes used in house heating plants.

In selecting a pipe covering, there should be taken into account not only its insulating properties but its ability to resist fire, dampness or breeding places for vermin. It rests entirely with the owner whether he covers the pipes with a combustible or an incombustible material when the insulating properties are abou: the same. Coverings made of animal or vegetable materials under some conditions furnish a breeding place for vermin.

Pipe coverings are made in sections about three feet in length and from 1 inch to 1 3-8 inches in thickness. The sections are usually cut in halves lengthwise to permit being put in place. The sections are covered with common muslin to keep the material in place and sometimes are painted after being installed. Painting has nothing to do wtih their insulating capabilities, but it preserves the cloth and makes a neat appearance. The sections when put in place are secured by pasting one of the loose edges of the cloth to the surface. The ends of the sections are bound together with strips of metal. Figure 31 shows the appearance of the pipe when the covering is in place.

Irregular surfaces like the body of the furnace, pipe connections, etc., are insulated by coverings made from a plaster that is made expressly for such work.

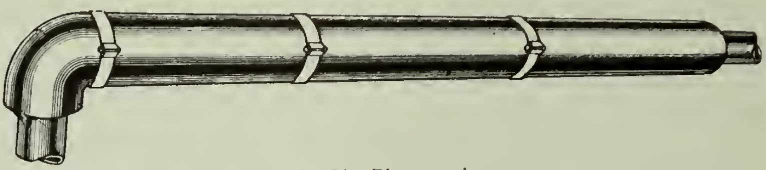


Fig. 31—Pipe covering.

It is known as asbestus plaster. The plaster may be purchased in bulk and put in place with a trowel. As it is found in the market the plaster requires only the addition of water to put into working form.

The value of a pipe covering is not in proportion to its thickness. Experiments with pipe coverings have shown that a thickness of 1 3-8 inches will reduce the radiation 90 per cent, but doubling the thickness reduces the loss only 5 per cent. It therefore does not pay to make a covering more than 1 3-8 inches thick.

CHAPTER II

The Hot-Water Heating Plant

Of the various systems of heating dwellings that by hot-water is considered by many to be the most satisfactory. On account of its high specific heat, water at a temperature much below the boiling point, furnishes the heat necessary to keep the temperature of the house at the desired degree. The temperature of the radiators is generally much lower than those heated by steam but the amount of radiating surface is greater than for steam heating plants of the same capacity. It is because of the relatively low temperature at which the water is used, that the greater amount of heating surface is required.

One objection to the use of hot water as a means of heating is, that once the heat of the house is much reduced, the furnace is a long time in raising the temperature to normal. This is due to the fact that the temperature of the water of the entire system must be uniformly raised, because of its continuous passage through the heater. On the other hand, this uniformity of the temperature of the water, prevents sudden changes in the temperature of the house. Water heating plants work with perfect quiet and may be so regulated to suit the outside temperature that the heat of the watr will just supply the amount to suit the prevailing conditions.

The care required in the management of the boiler is less than that required in the steam plant because of the fewer appliances necessary for its safe operation. Another advantage in the use of the hot-water plant is its adaptibility to the temperature conditions during the chilly weather of early fall and late spring, when a very small amount of heat is required. At such times the temperature of the radiators is but a few degrees warmer than the outside air. The amount of attention necessary for maintaining the proper furnace fire under such conditions is less than for any other form of heating. The increasing use of the hot-water plant for heating the average sized dwelling attests to its excellence in service.

The Low Pressure Hot-Water System: A hot-water system consists of a heater, in which the water receives its supply of heat, the circulating pipes for conducting the heated water to and from the radiators that supply heat to the rooms, and the expansion tank that receives the excess of water caused when the temperature is raised from normal to the working degree. In addition to the parts named there are a number of appliances to be described later, that are required to make the system complete.

A hot-water plant of the simplest form is shown in Figure 32. The illustration presents each of the features mentioned above, as in a working plant. The different parts are shown cut across through the middle; the black portion represenitng water. Not only does the water fill the entire system but appears in the expansion tank when the plant is cold.

Hot-water heaters are quite generally in the form of internally fired boilers. The fire-box occupies a place inside the boiler and is surrounded, except at the bottom, by the water-space. Commonly, these boilers are made of cast iron and are constructed in sections, the same as the steam boiler shown in Figure 16. Manufacturers sell a single style for either steam or hot-water heating. The boiler in Figure 32 is cylindrical in form. It is made of wrought iron and contains a large number of vertical tubes through which the heat from the furnace must pass on its way to the chimney.

As the water is heated it expands and rises to the top of the boiler because of its decreased weight. Since the water in the radiator is really a part of the same body of water, the heated portion rises through the supply pipe to the top of the radiator. As the hot water rises in the radiator, it displaces an equal amount of cold water, which enters the boiler at the bottom. This displacement is constant and produces a circulation that begins as soon as the fire is started and varies with the difference in temperature between the hot water leaving the boiler at the top and the cold water entering at the bottom.

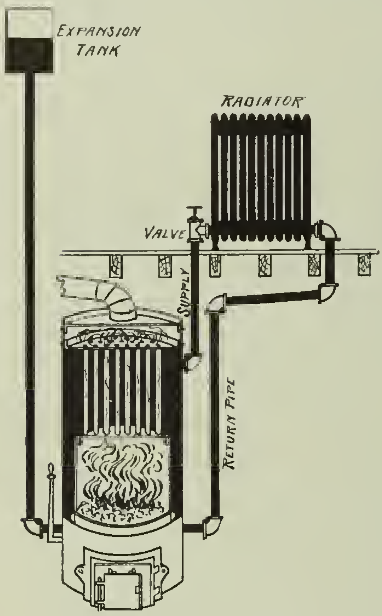


Fig. 32—A simple form of low-pressure hot-water heating plant.

As the water in the system is heated and expands, there must be some provision made to receive the enlarging volume. In this arrangement a pipe connects the bottom of the boiler with the expansion tank located at a point above the radiator. Under the conditions represented in the drawing the water does not circulate through the tank and as a consequence the water it contains is always cold.

In raising its temperature, water absorbs more heat than any other fluid and on cooling it gives up an equal amount. As a consequence it furnishes an excellent vehicle for transmitting the heat of the furnace to the rooms to be heated. Water, however, is a poor conductor and receives its heat by coming directly in contact with the hot surfaces of the furnace, and gives it up by direct contact with the radiator walls. To transmit heat rapidly and maintain a high radiator temperature, the circulation of the water in the system must be the best possible. The connecting pipes between the boiler and the radiators must be as direct as circumstances will permit and the amount of radiating surface in each room must be sufficient to easily give up an ample supply of heat. Even though the furnace is able to furnish a plentiful supply of heat to warm the house, it cannot be transmitted to the rooms unless there is sufficient radiating surface. A plant might prove unsatisfactory either because of a furnace too small to furnish the necessary heat or from an insufficient amount of radiating surface. Yet another factor in the design of a plant is that of the conducting pipes. Both the boiler and the radiators might be in the right proportion to produce a good plant, but if the distributing pipes are too small to carry the water required, or the circulation is retarded by many turns and long runs, the plant may fail to give satisfaction.

Figure 33 shows a complete hot-water plant adapted to a dwelling. It is just such a plant as is commonly installed in the average sized house but without any of the appliances used for automatic control of temperature. The regulation of the temperature is made entirely by hand, in so govering the fire as to provide the required amount of heat. In the drawing the supply and return pipes may be traced to the radiators as in the case of the simple plant. The supply pipe branches after leaving the top of the boiler, one pipe going to the right and the other to the left, making two complete circuits. To provide any radiator with hot water, a pipe is taken from the main supply pipe and passing through the radiator it is brought back and connected with the return pipe which conducts the water back to the boiler.

The expansion tank is located in the bath-room near the ceiling. It is connected with the circulating system by a single pipe which joins the supply pipe as it enters the radiator located in the kitchen. Like the expansion tank in Figure 31 the water it contains is always cold. It is provided with a gauge glass which shows the level of the water in the tank and an overflow pipe which discharges into the bath-tub, in case of an overflow. An overflow pipe must always be provided to take care of the surplus when the water in the system becomes overheated. This does not often occur

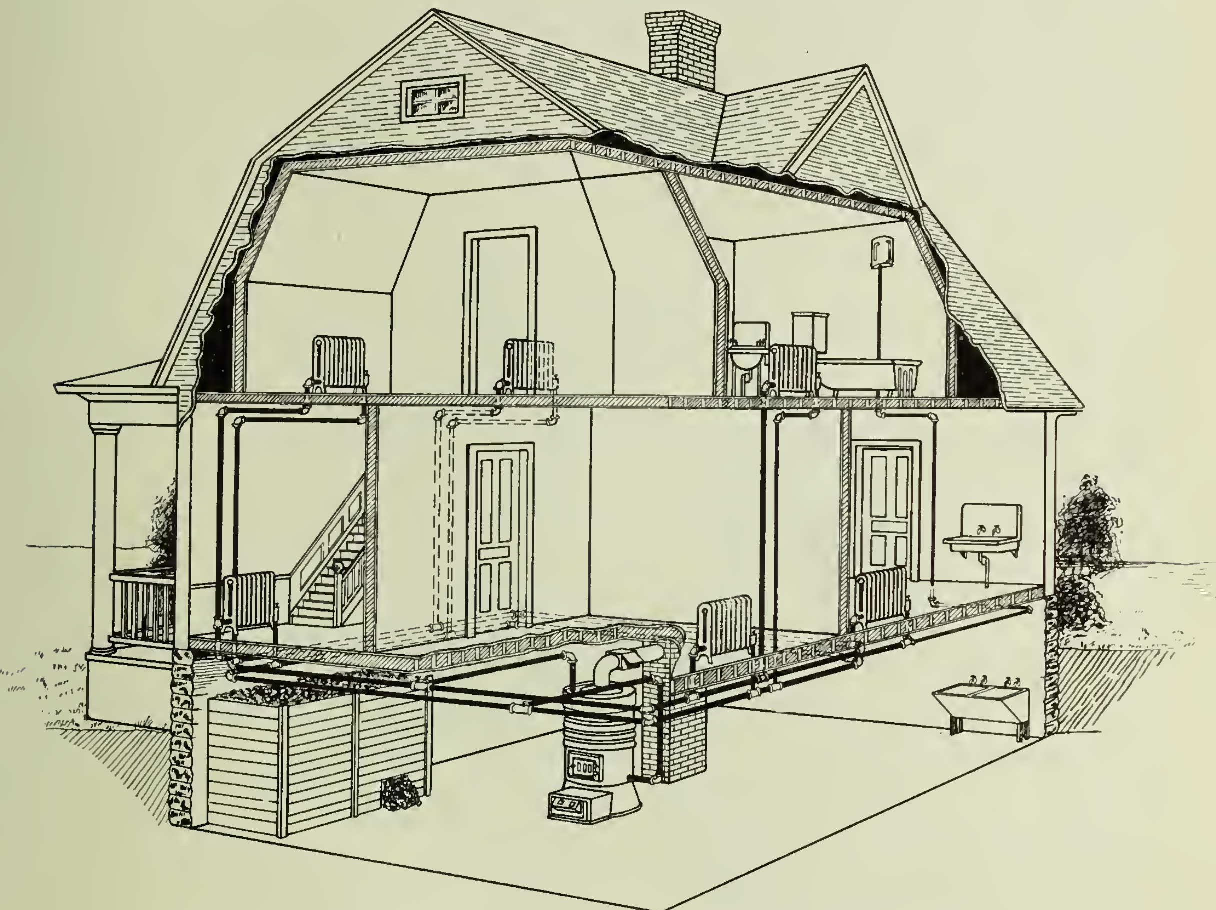


Fig. 33—The low-pressure hot-water heating system applied to a small dwelling.

but the provision must be made for the emergency. The overflow pipe is frequently connected directly with the sewer or discharged at some convenient place in the basement.

THE HIGH PRESSURE HOT-WATER SYSTEM: In the hot-water plant described the expansion tank is open to the air and the water in the system is subjected to the pressure of the atmosphere alone. The heat of the furnace may be sufficiently great to bring the entire volume of water of the system to the boiling point and cause it to overflow but the temperature of the water cannot rise much above the boiling point due to the pressure of the atmosphere.

If the expansion tank is closed, the pressure generated by the expanding water and the formation of steam will permit the water to reach a much higher temperature. In the table of temperatures and pressures of water on page 6 it will be seen that should the pressure rise to 10 pounds, that is, 10 pounds above the pressure of the atmosphere, the temperature of the water would be very nearly 240 (239.4) degrees F. The difference in heating effect in hot-water heating plants under the two conditions is very marked. In the low-pressure system the temperature of the radiators cannot be above 212 degrees but the high-pressure system set for 10 pounds pressure will heat the radiators to 240 degrees, and a still higher pressure would give a correspondingly higher temperature. The amount of heat radiated by a hot body is in proportion to the difference in temperature between the body and the surrounding air. If we consider the surrounding air at 60 degrees the difference in amount of heat

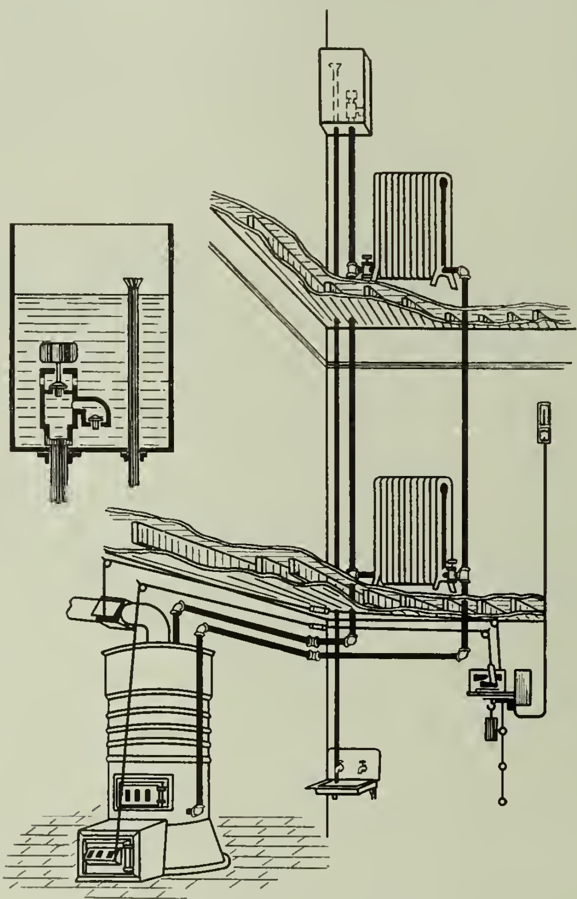


Fig. 34—The high-pressure system of hot-water heating.

radiation capacity of the two radiators would be as 180 is to 132. The advantage of the high pressure system lies in its ability to heat a given space with less radiating surface than the low pressure system.

In Figure 34 is illustrated an application of a simple and efficient valve arrangement that converts a low pressure hot-water system into a high-pressure system without changing in any way the piping or radiators. The drawing shows the boiler and two radiators connected as for a low-pressure system, but attached to the end of the pipe as it enters the expansion tank is a safety valve—and a check valve. The safety valve is intended to allow the water to escape into the expansion tank when the pressure in the system reaches a certain point for which the valve is set, and the check valve permits the water to re-enter the system from the tank whenever the water cools sufficiently to require an additional amount to keep it full.

Suppose that such a system is working as a low pressure plant. The hot water from the top of the boiler is flowing to the radiators through the supply pipe and the displaced cooler water is returning to the bottom of the boiler through the return pipe as in the other plants described. It is now found that the radiators are not sufficiently large to heat the rooms to the desired degree except when the furnace is fired very heavily. It is always poor economy to keep a very hot fire in any kind of a heater because a hot fire sends most of its heat up the chimney. If the radiators could be safely raised in temperature they would of course give out more heat and as a result the rooms would be more quickly heated and kept at the required temperature with less effort by the furnace. The difficulty in this case lies solely in there bing insufficient radiator surface to supply heat as fast as required.

This is accomplished by the pressure regulating valve attached to the end of the pipe as it enters the expansion tank. The valve is kept closed by a weight that is intended to hold back a pressure of, say ten pounds to the square inch. A pressure of ten pounds will require a temperature of practically 240 F. When the pressure of the water goes above ten pounds, or the amount of the weight is intended to hold back, the valve is lifted and an amount of water escapes into the tank, sufficient to relieve the pressure. Should enough water be forced out of the system to fill the tank to the top of the overflow pipe, the overflow water is discharged through this pipe into the sink in the basement.

When the house has become thoroughly warmed the demand for a high radiator temperature is reduced, the furnace drafts are closed, the water in the system cools and as it shrinks the system will not be completely filled. It is then necessary to take back from the tank the water that has been forced out by excess pressure. It is here that the check valve comes into use. So long as there is pressure on the pipes, this valve is held shut and no water can escape, but as the inside pressure is released by the cooling there will come a point where the water in the tank will flow back through the valve and fill the system.

This is the type of valve used by the Andrews Heating Company and designated, a Regurgitating Valve. In practice it gives excellent service. The only danger of excessive pressure in the use of such a valve is the possibility of the valve becoming stuck to the seat through disuse. This possibility may be eliminated by occasionally lifting the valve by hand.

A heating plant should be designed by a person of experience. No set of rules has yet been devised that will meet every condition. Carpenter's rules given on page 21 serves for hot water as well as for steam as a means of determining the radiating surface required for an ordinary building, but the rules do not take into account the method of construction of the house and the consequent extra radiation demanded for poorly constructed buildings. In many cases the designer must rely on experience as a guide where the rules will not apply. In the cases usually encountered, however, the rules given will meet the conditions.

What was said regarding the size of steam boilers required for definite amounts of heating surfaces, applies with equal force to hot-water boilers, because house-heating boilers are commonly used for either steam or hot-water heating. There are no established rules for determining the heating capacities of house heating boilers. Manufacturers' ratings are usually low. There are some manufacturers who make honest ratings for their boilers but they are in the minority. When the heating capacity of a boiler is not known from experience, the only safeguard against installing a boiler too small for the radiators to be heated, is to require a guarantee that the plant will give satisfaction when in operation and when considered necessary a certain percentage of the contract price should be with-held until the plant proves itself by actual trial.

OVERHEAD SYSTEM OF HOT-WATER HEATING: In Figure 35, is illustrated another system of high-pressure hot-water heating that corresponds to the overhead

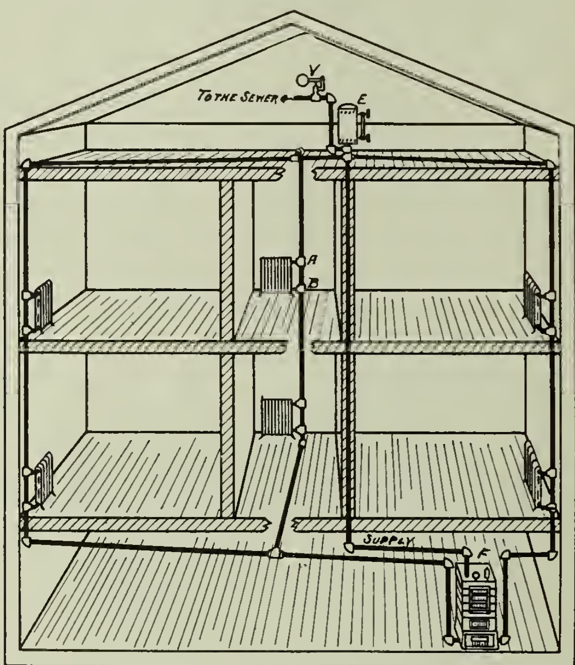


Fig. 35—The overhead system of hot-water heating.

system of steam heating. It differs from the high-pressure system already described in the method of distribution and in the radiator connections.

The flow pipe is taken to the attic and there joined to the expansion tank as a point of distribution. On the expansion tank is a safety valve set at 10 or more pounds pressure. The flow of the water is all downward toward the radiators. The circulation through the radiators is also different from the other plants described. The supply pipe joins directly to the return pipe and the connections to the radiators are made at the top and bottom of the same end. The circulation through the radiators

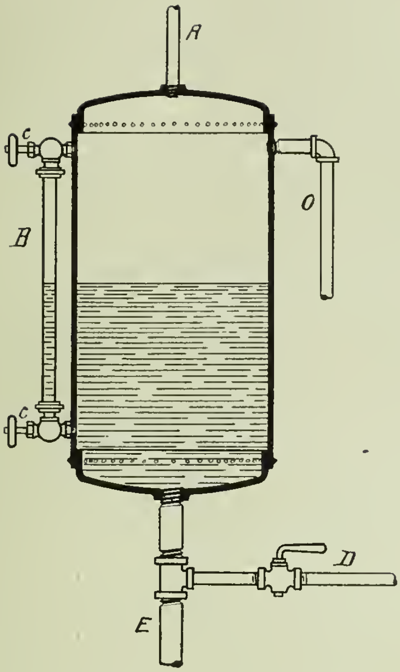


Fig. 36—The expansion tank.

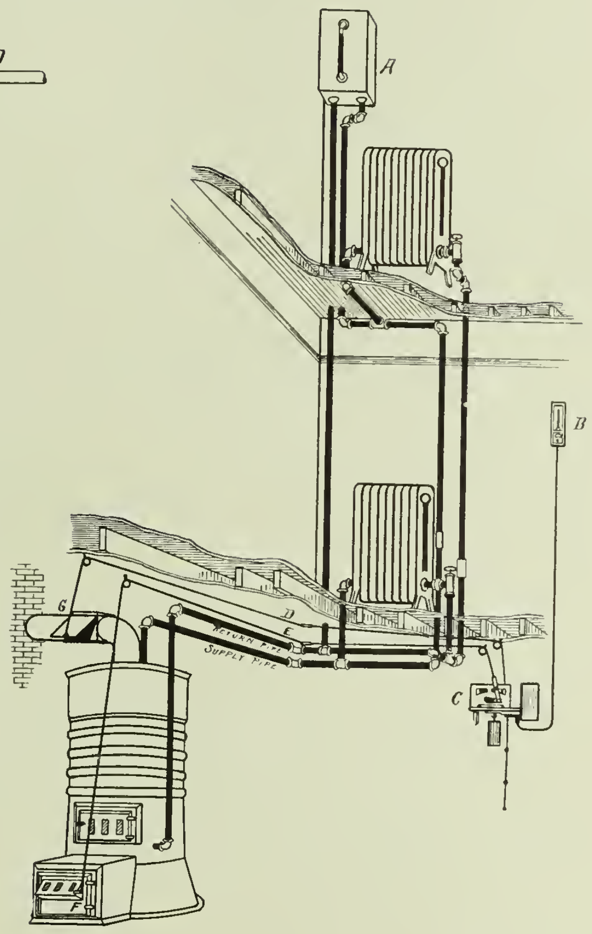


Fig. 37—When the expansion tank of a hot-water heating system must be so located that it is apt to freeze, it must be piped as a radiator.

in this case is due to the difference in gravitational effect between the hot and colder water at the top and bottom of the radiator. The system requires no air vents on the radiators as all air that might collect in the system goes up to the expansion tank. The safety valve on the expansion tank in this case is the common lever type. The overflow should empty into the sewer and be pitched to prevent any water being retained in the discharge pipe. If water should be retained in this pipe and should freeze the system would become a dangerous one.

EXPANSION TANKS: Figure 36 is a form of expansion tank in common use. It may be used for either the high or low pressure system. The body of the tank is made of galvanized iron and is made to stand a considerable amount of pressure. The gauge glass is attached at B, and the overflow at O. The pipe E connects the tank with the circulating system and D connects with the cold water supply as a convenience for filling the system with water. The object in placing the stop cock D near the expansion tank is to avoid overflowing the system in filling. The overflow pipe, as stated above is most conveniently connected with tne sewer, into which the water will run in case of an overflow, but the other methods shown are commonly used. There should be no valve in this pipe nor in the pipe E.

The expansion tank must be so located that there will be no danger of freezing. Should it be necessary to place the tank in the attic or where freezing is possible, the tank must be so connected as to become a part of the circulating system. Such an arrangement is shown in Figure 37. The expansion tank is connected with a supply and return pipe as a radiator. This arrangement is sometimes used but it is not desirable. It is wasteful of heat and there is always a possibility of freezing in case the fire in the furnace is extinguished a sufficient time to allow the water to grow cold.

Any possibility of danger from excessive pressures in either the low-pressure or the high-pressure system must originate in the expansion tank. It is therefore desired to again mention the possible causes of danger. Any closed tank system is liable to become overheated. The expansive force of water is irresistable and unless some means is taken to prevent excessive pressure some part of the apparatus is apt to burst. *No closed-tank system should be used without a safety-valve.*

The low-pressure or open-tank system requires no safety appliances. So long as there is open communication between the tank and the boiler the pressure cannot rise but slightly above that of the atmosphere. There is only one cause that will lead to high pressure in such a system. If the pipe connecting the expansion tank is stopped an excessive pressure might generate. There is little or no danger of this happening.

In the closed-tank system the expansion tank should be of greater capacity than for the open-tank system. Its size is commonly about one-ninth of the volume of water used. The larger tank is necessary to prevent too rapid rise of pressure as the temperature of the water rises. The air in the tank acts as a cushion against which the pressure of the expanding water is exerted.

The extended use of hot-water heating has led to the invention of many appliances for the improvement of the circulation and heating effects. Pulsation valves are used for retaining the water in the boiler until a definite pressure has been attained that will lift the valve long enough to dissipate the pressure. Many of these systems possess merit and some of them are great improvements over the simple plant.

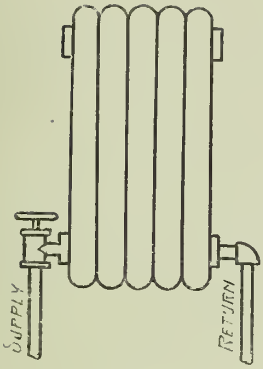


Fig. 38.

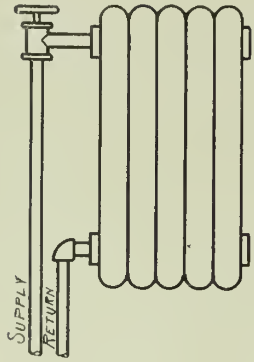


Fig. 39

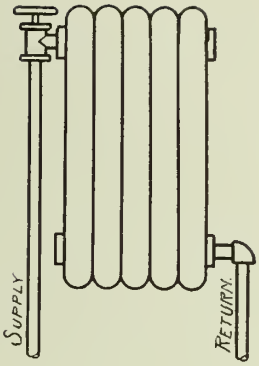


Fig. 40.

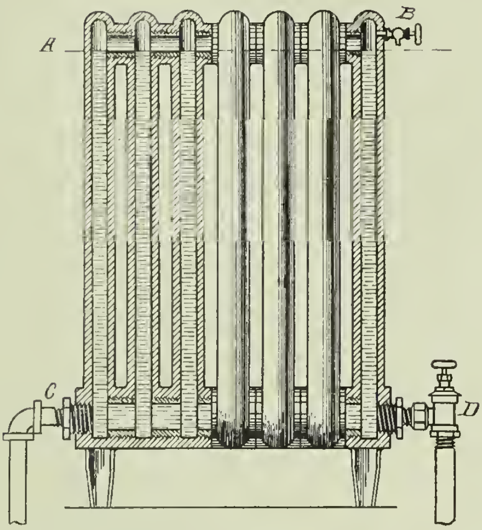


Fig. 41—The effect of accumulation of air in a hot water radiator with bottom connections.

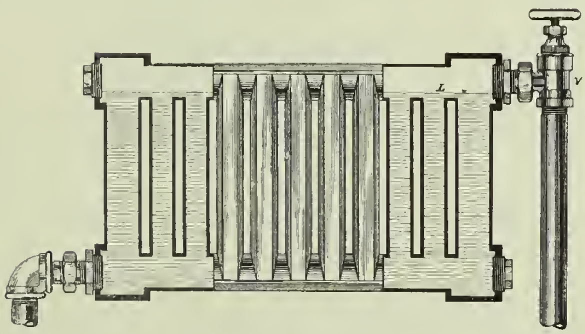


Fig. 42—With this method of connections, if the air collects sufficiently to force the water down to the level L, circulation will stop.

Radiator Connection: The method of connecting the radiators to the distributing pipes depends entirely on local conditions. In a well balanced system any of the methods shown in Figures 38, 39 or 40 might be used with good heating effects. The method of attaching the supply pipe to the radiator is, however, an important factor in case of accumulation of air. In Figure 41 is shown the form of connection most commonly used. The drawing is intended to represent a cast iron radiator with the valve at D, and the air vent at B. Should air collect in the radiator it will rise to the top and displace the water. The water will continue to circulate and heat as much of the radiator as is in contact with the water, but that part not in contact will receive no heat from the water and will therefore fail to fulfill its function. As soon as the air vent is opened the air will escape and allow the water to entirely fill the space.

In Figure 42, a much different condition exists, when air accumulates. In this mode of connection the water enters through the valve V, and escapes at the bottom of the opposite end. When air fills the radiator to the line L, the circulation is stopped and the radiator will grow cold.

The position of the valve on these radiators is of little consequence. The valve is intended merely to interrupt the flow of the water and may occupy a place on either end of the radiator with the same result.

Hot-Water Radiators: Radiators for hot-water heating are most commonly of cast iron and in appearance are the same as those used for steam heating. The only difference in the two forms is in the openings between the sections. Those intended for steam, have an opening at the bottom joining the sections; while those for hot-water have openings at both top and bottom to permit circulation of the water.

Hot-Water Radiator Valves: Valves for hot-water radiators differ materially from those used on steam radiators. Figures 43 and 43-A show the outside appearance and the mechanical arrangement of the parts, of the Ohio Hot-Water Valve. The part A in Figure 43-A is a hollow brass cylinder attached to the

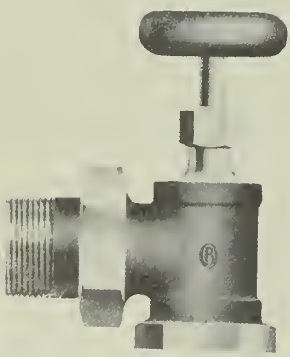


Fig. 43—The hot-water radiator valve.

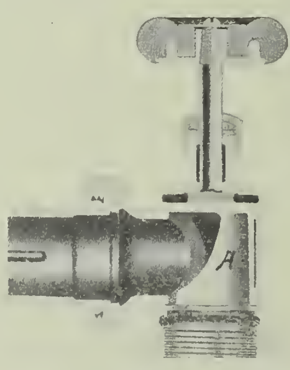


Fig. 43-A—Details of construction of the hot-water radiator valve.

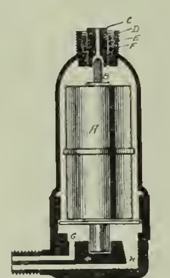


Fig. 44 — Automatic air vent for hot-water radiators.

valve stem, one side of which has been removed. When it is desired to shut off the supply of heat the handle of the valve is given one-quarter turn and the part A covers the opening to the inlet pipe. The supply of water being shut off the radiator gradually cools. When the valve is closed a small amount of water is admitted to the radiator through a one-eighth inch hole in the piece A to prevent the possibility of freezing.

AIR VENTS: In the use of the systems of hot-water heating described, every radiator must be supplied with an air vent of some kind to take away the trapped air which accumulates through use. Any kind of a valve will serve as a vent for hand regulation and generally such a cock as is shown in Figure 10 is employed.

AUTOMATIC HOT-WATER AIR VENTS: It is sometimes desired to use automatic air vents on hot-water radiators. For such work a vent is used that remains closed as long as water is present and will open when the water is displaced by the accumulating air, but will again close when the air is discharged. In such vents the valve is controlled by a float, the buoyancy of the float when surrounded by water serving to keep the valve closed. These vents are not so positive in their action as automatic air vents for steam. The change in temperature which controls the steam vent does not take place with hot-water. The automatic hot-water vents are not perfectly reliable. They may may work with entire satisfaction for a long time and then fail from very slight cause. The failure of a hot-water vent is generally discovered by finding a pool of water on the floor or a wet spot on the ceiling or wall of the floor below.

One type of the automatic hot-water vent that has proven quite successful is shown in Figure 44. The threaded lug is screwed into the radiator at the proper point. As the water enters the radiator the air is discharged through the vent, escaping at the opening C. When the water has risen to a sufficient height it enters the openings G and H until enough is present to raise the float A. The pointed stem attached closed the hole C with sufficient force to make an air-tight joint. The float A is a very light copper cylinder. It's buoyancy supplies the force to close the vent and its weight opens the vent when the water is displaced by air. It will be readily seen that very slight cause might prevent the performance of its duty.

CHAPTER III

The Hot-Air Furnace

Of the methods of heating dwellings other than by stoves, that of the hot-air furnace is the most common. Of the various modes of furnace heating it is the least expensive in first cost and most rapid in effect. In the use of steam heat, the water in the boiler must be vaporized before its heat is available. With hot-water heating, the whole mass of water in the entire system must be raised considerably in temperature before its heat can affect the temperature of the rooms; and consequently in first effect it is very slow. In the use of the hot-air furnace the heat from the register begins to warm the rooms when the fire is started.

Hot-air furnaces are made by manufacturing companies in a great variety of styles and forms to suit purposes of every kind. In practice the furnace is built in sizes, to heat a definite amount of cubical space. The maker designs a furnace to heat a certain number of cubic feet of space contained in a building. It must be sufficiently large to keep the temperature at 70 degrees Fahrenheit on the coldest nights of winter when the wind is blowing a gale. It is evident that with the variable factors entering the problem, the designer must be a person of experience in order that the furnace meet the requirements.

The following table taken from a manufacturer's catalogue shows the method of adapting the product of the maker to any size of dwelling. The volume of the house in cubic feet is calculated and from the amount thus determined a furnace is selected from the table that most nearly suits the conditions.

Furnace number	1	2	3	4	5
Weight without casing	984 lbs.	1,111 lbs.	1,340 lbs.	1,531 lbs.	1,934 lbs.
Estimated capacities in cubic feet	8,000 to 12,000	12,000 to 20,000	20,000 to 35,000	35,000 to 60,000	60,000 to 100,000
Capacity, in No. of rooms of ordinary size in residence heating	3 to 5	5 to 7	7 to 9	9 to 12	12 to 15

CONSTRUCTION.

The furnace, in general construction, consists of a cast-iron fire-box with its heating surfaces, through which the flames and heated gases from the fire pass, on the way to the chimney; these with the passages and heating surfaces for heating the air compose the essential features. Figure 45 shows such a furnace with the sides broken away to show the internal construction. The flames and gases from the fire-box F, circulate through the cast iron drum D, and are discharged at C to the chimney. The drum D is made in such form that it presents to the heat from the fire a large amount of heating surface and at the same time offers as little opposition as possible to the furnace draft. The air to be heated, enters the furnace through the cold air duct at the bottom, and after circulating through the drum, passes out at the openings R, to the conducting pipes. The cast iron box W, is a water tank that should be attached to every hot air furnace. The water contained in the tank

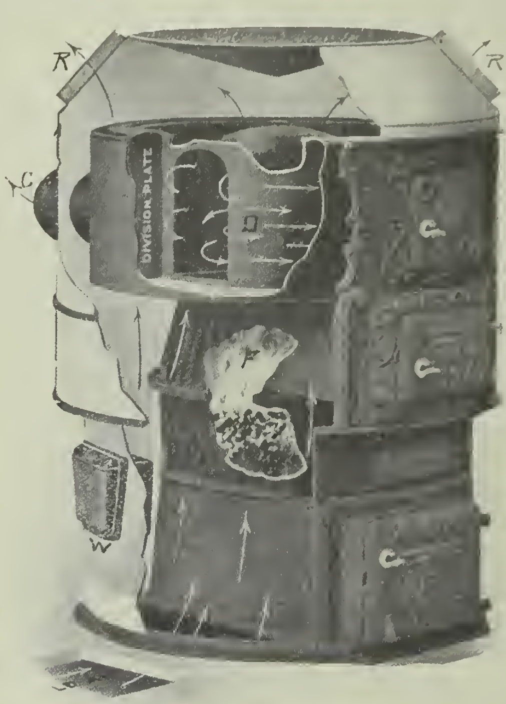


Fig. 45—Hot-air furnace showing the internal construction and the method of admission and discharge of the air used in heating the house.

is for humidifying the air as it passes through the furnace. In this furnace the outside casing is of sheet iron, reinforced with wrought iron flanges. The front, which contains the doors of the fire box, ash pit, etc., are of cast iron of ornamented design.

As the air to be heated passes through the furnace it receives part of its warmth by radiation but most of it is absorbed by coming directly in contact with the heating surfaces. Since air is a poor conductor of heat its temperature is raised very slowly; it should therefore be kept in contact with the heating surfaces as long as possible to insure an economical furnace. In common practice the ratio of heating surface to grate surface average 35 to 1; that is for each square foot of grate surface there is 35 square feet of heating surface to warm the passing air. Should this ratio be increased to 50 to 1 the efficiency of the furnace would be much improved.

If the ratio of heating surface to the grate surface is too small for its requirements, the temperature of the air heating surfaces must be very high to provide the desired amount of heat. Under such a condition the efficiency of the furnace would be low; since in all cases where rapid combustion is required, the available amount of heat per pound of coal consumed is low. With a large amount of heating surface, the air remains in contact with the hot surface a relatively longer period and the desired temperature is reached with the expenditure of a smaller amount of fuel. A momentary exposure of the air to a red-hot surface is far less effective than a prolonged contact with a surface having only a moderate temperature. Time is an element of great importance in heating air. In considering the relative merits of two furnaces with the same amount of grate surface, that with the larger amount of heating surface will evidently be the most efficient.

The supply of heat comes primarily from the burning coal on the furnace grate. The grate surface should be large enough in area to permit the required quantity of heat to be generated by the burning fuel with a moderate fire. If the grate surface is too small for the required purpose, a hot fire will be necessary, when the normal amount of heat is demanded by the house. During extremely cold weather, particularly when accompanied by high wind, the extra heat demanded to keep the house at the desired temperature makes necessary the use of an amount of fuel that cannot be burned on the grate unless the fire is forced. Hot fires can only be kept up at the expense of a large amount of heat, and the resultant efficiency of the furnace is reduced.

High furnace temperatures are always attended by a large loss of heat. The vastly greater quantity of air necessary to create the combustion, the high temperature of the chimney gases and the increased velocity of the heated gases through the furnace, all tend to increase the amount of heat that is sent up the chimney, and to decrease the percentage of heat per pound of fuel that is delivered by the furnace. In order to heat the house economically the furnace must be large enough in size to easily generate the required amount of heat demanded in the most severe weather.

LOCATION.

The location of the furnace will generally be governed by the exposure of the house and the location of the chimney. In all exposed rooms on the windward side of the house the temperature will be lower and the air pressure higher than in other parts of the house. The increase in atmospheric pressure makes it necessary to supply to such rooms the hottest air practicable. The conducting pipes therefore should be most directly connected with the furnace and with the least run of horizontal pipe. The proper place for the furnace is as near as possible the coldest place of the house.

It is a common practice to place registers near the inner corner of the room, in order to economize in conducting pipe, in horizontal runs. A small amount of economy in first cost is thus secured but the efficiency of the apparatus is sacrificed.

The greatest objection to placing the registers and conducting pipes, in the outer walls of building is that of loss of heat, due to exposure to the outside cold and the resulting loss in circulation. Losses of this kind may be prevented by covering the ducts with the necessary non-conducting material. The registers should occupy a place in the room nearest the entering cold air.

FLUES: It is customary to place the conducting pipes for the first floor in such a way as to use only the shortest connections. The flues used for the second floor, produce as in a chimney, a greater velocity of flow to the air and as a consequence larger *horizontal* pipes are used at the furnace. All horizontal pipes should have upward slant, as much as the basement will permit.

The velocity of the air in the conducting flues will depend on two factors; the height of the flue and the temperature of the air. To prevent the fall of the temperature of the air, the flue should be covered with at least two layers of asbestos paper bound with wire. Wall flues are commonly flattened and occupy a place in the wall between the studding. Each flue should have a damper at the furnace, that will permit the heat to be shut off from any part of the house.

Rules for proportioning of registers and conducting flues to suit rooms of various sizes are entirely empirical. The sizes of registers and flues found satisfactory in practice is generally a guide for the designer. The following table is taken from a manufacturer's catalogue and gives a list of sizes that have proven satisfactory under a great variety of conditions and may be taken as good practice:

FIRST FLOOR

Sizes of Registers in inches	Diameter of Pipes in inches	Size of Rooms in feet	Height of Ceilings in feet
12 x 15	12	18 x 20	11
10 x 14	10	15 x 15	10
9 x 12	9	14 x 15	9
8 x 12	9	13 x 13	9

SECOND FLOOR

10 x 14	10	18 x 20	10
9 x 12	9	16 x 16	9
8 x 12	8	13 x 13	8
8 x 10	7	12 x 12	8

The furnace is not only a means of heating the house but may be a means of ventilation as well; to this end it is desirable to arrange the air supply of the furnace to connect with the outside air. This arrangement assures a supply of oxygen even though no special means is arranged for discharging the vitiated air from the rooms.

In the case of large houses heated by hot-air it is sometimes better to use two or more furnaces than to attempt to carry the heat long distances in the customary pipes. Where heat is required in rooms located at a distance more than thirty feet, it is advisable to use a combination Hot-air and Hot-water heater, the distant rooms being heated by hot-water radiators.

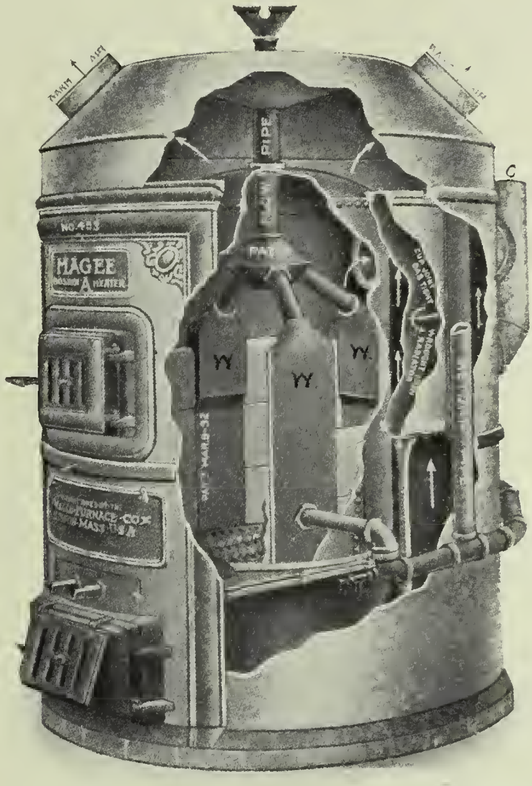


Fig. **46**—Combination hot-air and hot-water furnace with the sides removed to show the internal construction.

A furnace arranged for such a combination is shown in Figure 46. This furnace contains first, the essential features of a hot-air furnace, next it includes a hot-water plant. The fire-box and air heating surfaces are easily recognized. The arrows show the course of the air entering at the bottom of the furnace, which after being heated by passing over the heating surfaces, escapes at the openings marked *warm air*, to the distributing pipes.

Inside the air heating surfaces are three hollow cast-iron pieces W, that form a part of the walls of the fire-box. These pieces with their connecting pipes, form the water-heating part of the furnace, which supplies the hot water for the radiators. The pieces W, with the connecting pipes and radiators form an independent heating plant, with a fire-box in common with the hot-air furnace.

The returning water from the radiators enters the heating surfaces W, through the pipe marked *return pipe*. The heated water is discharged from the heaters into that marked *flow-pipe* which conducts it to the radiators. Such a furnace is therefore, two independent systems one for hot-air and the other for hot-water, but with a single fire-box. This furnace, like the simple hot-air furnace, is rated, first in the amount of space it will heat with hot air and then by the number of square feet of hot-water radiating surface will be kept hot by the hot-water heater.

In Figure 47 is shown the location of the furnace in a cottage with the conducting pipes to the various rooms. The registers in the first floor are generally set in the floor but if desired they may be placed in the walls. Those on the second

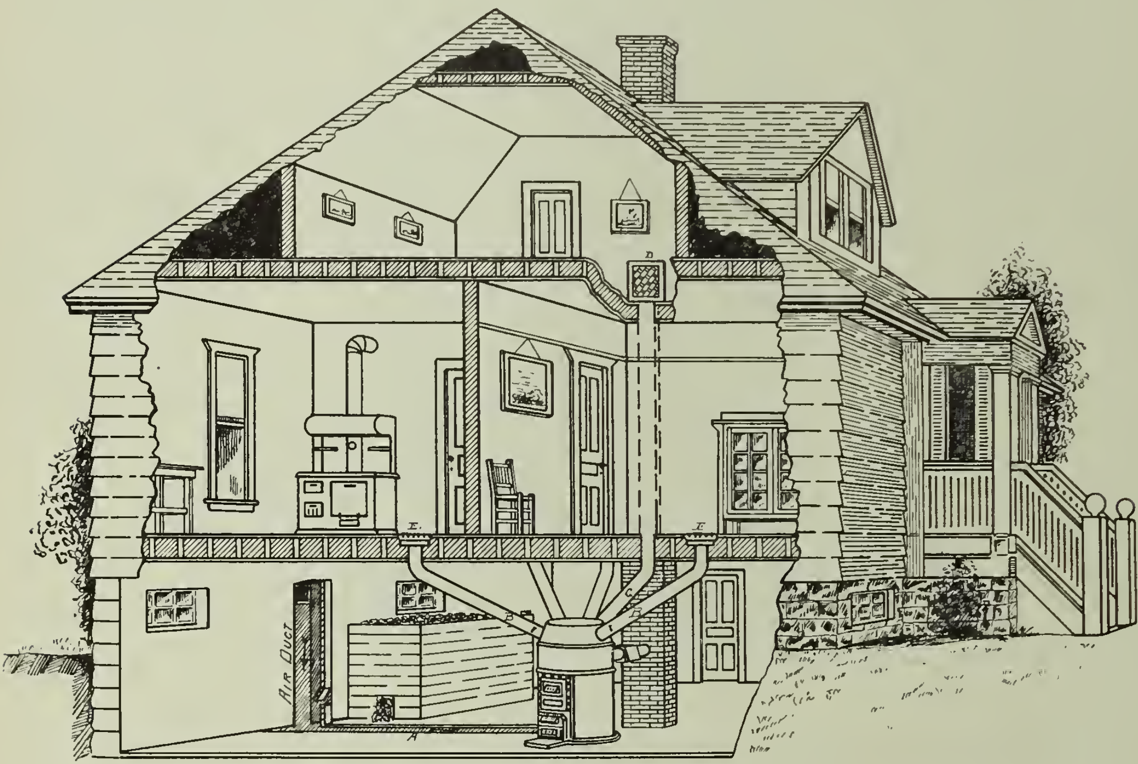


Fig. 47—The hot-air furnace as it appears in the house.

floor are placed in the walls because of convenience. The conducting pipes pass through the partitions between the studding.

In all well arranged hot-air heating plants provision is made so that the air for heating may be taken from the outside. It does not follow that the supply of fresh air should always come from outdoors; there are times during extremely cold weather, accompanied by high winds, when ventilation is ample without the outside source of supply. Since it is never desirable to take the air supply from the basement, such an arrangement as is shown in Figure 48, or a modification of the same plan is commonly employed. The duct A from the outside and B from the rooms above connect with the air supply for the furnaces. A damper C, is arranged to move on a hinge, so as to take the air from either source as desired. The damper may be placed so as to take part or all of the air from the outside by adjusting the handle at the proper place.

Ventilation: In the construction of dwellings of moderate cost, little or no thought is taken of a way for discharging air from the home. The desire to keep warm, prompts us to shut the house up as tight as possible and pay little regard to the discomfort and evil effects of breathing impure air. Even with the arrangement of a heating plant, provided for admitting fresh air, no direct passage is arranged by means of which the stale air may be exhausted.

Unless some arrangement is made for an occasional complete change of air, the atmosphere of the house in the winter will become so vitiated that it fails entirely in

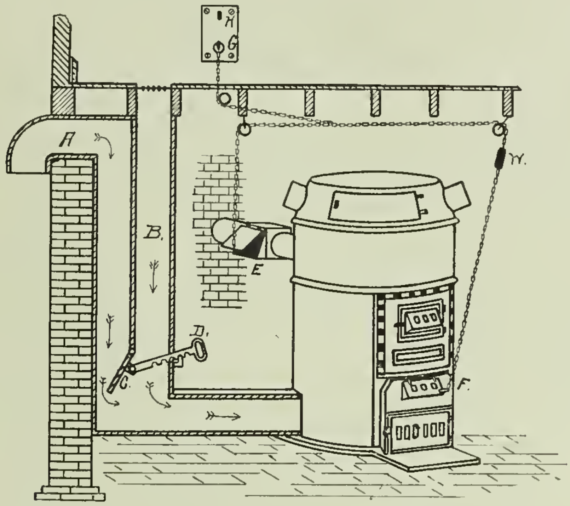


Fig. 48—Details of air ducts and damper regulator used with the hot-air furnace.

its stimulating effects. The air of a house may become so heavily freighted with occluded gases and animal vapors that even though fresh air is admitted, it will only serve to dilute the vitiated condition. It is common to hear a competent housekeeper say: "The house ought to be aired." This is accomplished by opening the doors and windows so as to provide a draft that will carry away the old air and replace it with a new clean supply.

In large buildings this is accomplished by a system of forced ventilation, where the air is driven into the interior of the building by a fan and carried to the various rooms by a system of ducts. Similar passages are provided for the escape of a like amount of old air from each room. It has come to be recognized by architects that the so-called "natural system of ventilation" will not ventilate large buildings, but for small buildings it answers very well. The natural system is that of arranging a chimney flue that will act as a means of exhaust and constantly discharge the air from a building. Such an arrangement is shown in Figure 49. In this house the chimney has three flues. The flues A, and C, carry away the smoke from the kitchen range and furnace. The flue B, is a vent for the house through which is discharged a constant stream of air.

In the picture are shown two registers, R and S, placed near the floors on the first and second stories. This flue creates a draft that carries away the air of the room which is constantly being replenished by the air from the heating registers. A fire-place makes an excellent ventilating device for the reason that it carries away a great amount of air from the house that would have no other means of escape.

· ATMOSPHERIC HUMIDITY: In the description of the Hot-Air Furnace reference was made to the water tank W, in Figure 40, the office of which is to supply the amount of water vapor necessary to render the air most desirable. The subject, Relative Humidity, is discussed in all text books of Physics, but little reference is made to its effect on general health. The following bulletin from the Department of

Fig. 49—A chimney flue used as a ventilator.

Health of Chicago describes briefly the effect of dry air and also the method of constructing a simple Hygrometer.

INDOOR HUMIDITY: "Outdoor air is pure and life-giving. This is not true of indoor air, as a rule.

To secure ideal conditions as to the air we breathe in our homes and work places, it is important that it approach as nearly as possible that of out of doors. This applies as to both purity and moisture, and both these requisites are of the utmost importance as affecting our health.

Normal outdoor air at a temperature of 70 degrees, contains about 70 per cent of watery vapor. In the summer time, there is, as a rule, sufficient moisture in the air to render it most beneficial. It sometimes happens that there is an excess of moisture and when this happens, even with a temperature of not over 70 degrees, the weather will be most uncomfortable. This means that we feel the heat more than we would with the thermometer touching 90 and the air normally dry.

But in the winter when most people keep their homes closed and with a heated temperature of 70 to 74 degrees, the moisture is soon absorbed and the air becomes very dry and unhealthful. Especially is this true in buildings and flats that are heated by steam.

Some years ago the Department of Health issued a bulletin on this subject of indoor humidity and called attention to the fact that with the increasing number of steam-heated living apartments in the city there was also a marked increase in pneumonia, as shown by the death rate from this disease. Now, this increase of pneumonia was due to bad air in the homes. And, according to good authority, the lack of proper moisture in the air was the principal factor.

In homes heated by hot air furnaces the air in the rooms is kept sufficiently moistened by hot water pans set in the furnaces. It is also possible to attach a receptacle containing water to radiators and in this way moisten the air in steam-heated apartments.

While it is comparatively an easy matter to provide means of moistening our indoor air, it has not been so easy to determine the degree of humidity. That is, to tell whether the air is too dry or too moist. This is determined by an instrument called a hygrometer. An instrument of this kind, that is fairly accurate, can be made by using the following formula:

Cobalt Chloride	5 drams
Sodium Chloride	150 grains
Calcium Chloride	40 grains
Gum Arabic	80 grains
Water	2 ounces

Dissolve carefully and then soak thin white muslin in the solution and wring dry; when dry cut into strips for use and hang up in rooms where indications are desired. The muslin strips when dry are blue; when moist they are pink or red. If the air in your room contains 70 per cent humidity, the muslin indicator, prepared as directed, would show pink. If there be only 60 per cent or less, the color will be blue. So, too, if the strip assumes a grayish color inclining to pink, it would indicate, at a temperature ranging from 68 to 72 degrees, a normal and therefore healthful degree of humidity in the air.

There is, too, an economic as well as a health side to the matter of having the proper degree of moisture in our indoor air. It is a well-known fact that a room is more comfortable at a temperature of 68 degrees and a relatively humidity of 65 per cent, than it is at a temperature of 72 degrees and a relative humidity of only 30 per cent. In fact, it has been determined that as a rule indoor air contains far too little moisture, probably 40 per cent less than that found out of doors. This means that the air in most of our homes is dryer than the dryest climate to be found anywhere on earth.

The point to all we have been saying is this: When the air in our homes or working places is lacking in moisture it tends to produce pneumonia, catarrh, bronchitis, and other diseases of the respiratory tract. The dry atmosphere absorbs the moisture from the lungs and membranous linings of the air passages, thus causing irritation and disease. With a hygrometer such as we have described, it will be easy to tell approximately, at least, when the air is too dry, and with just a little care and attention much more healthful conditions may be maintained."

Humidifiers for houses heated by steam or hot-water are made in the form of sheet metal tanks that are made to hang on the back of the radiators. These tanks are kept filled with water which evaporates and raises the humidity of the air. In houses heated by hot-air, in addition to the water tank in the furnace, humidifiers are made to set under the registers so that the air as it enters the room will take up a still further amount of moisture."

CHAPTER IV

Temperature Regulation

The method used for regulating the temperature of a house will depend on its size, the conditions under which it is to be used and the method of heating. In small houses the temperature may be satisfactorily governed entirely by hand, that is the furnace drafts may be changed by hand to suit the varying conditions of temperature. A more satisfactory method is that of thermostatic regulation, in which a thermostatic governor and a motor automatically control the furnace dampers so as to keep a constant temperature at one point, generally the living room. Where hot-water or steam heating plants are used another device is frequently employed to keep the temperature of the heat supply at a constant degree. This is known as the automatic damper regulator. The damper regulator is one of the boiler accessories which so governs the drafts of the furnace as to keep a constant water temperature in the hot-water heater or a contant steam pressure in the steam boiler.

In some cases both the damper regulator and the thermostat are used as a more complete means of temperature control.

HAND REGULATION: As a means of changing the dampers of the furnace from the floor above, to suit the prevailing conditions, the arrangement shown in Figure 48 does away with the necessity of a journey to the basement, to remedy each change of temperature.

A plate is fastened to the wall at any convenient place, to which the end of a chain is attached as shown in the figure. This connects with a second chain, the ends of which are fastened, one to the direct-draft or ash-pit damper F, and the other to the check-draft L, in the chimney. As the furnace appears in the drawing, the direct draft is closed and the check draft is open. By changing the ring from G to H, the movement of the chain opens F, and closes E, admitting air to the furnace. When the temperature of the room is raised sufficiently, the drafts are restored to their original position by replacing the ring at G. Sometimes one or more intermediate points are made on the plate between G and H, which permits both drafts to be kept partly open and fewer changes are required to keep the temperature approximately normal.

DAMPER REGULATOR FOR STEAM BOILER: The damper regulator used on a steam boiler is a simple device that automatically controls the draft dampers by reason of the changing pressures of the steam. The object of the damper regulator is to prevent the generation of steam in the boiler beyond a certain pressure at which the valve is set. This point is usually three or four pounds below the pressure at which the safety valve would act. If in proper working order the damper regulator will so control the dampers that the boiler will always contain a supply of steam, but the pressure will not reach a point requiring the action of the safety valve. Figure 51 illustrates its connections with the furnace dampers. In Figure 18 the regulator appears at D. In external appearance and in operation of the dampers, it is the same as the regulator for a hot-water boiler but its internal construction is simpler.

Figure 50 shows its construction. It is attached to the steam space of the boiler at E. The steam pressure acts directly on the flexible metallic diaphragm B. As the pressure of the steam approaches the desired amount the diaphragm is raised and with it the lever V. A chain D, attached to the end of the lever, opens the check draft, and another at C closes the draft damper. When the steam pressure falls, the

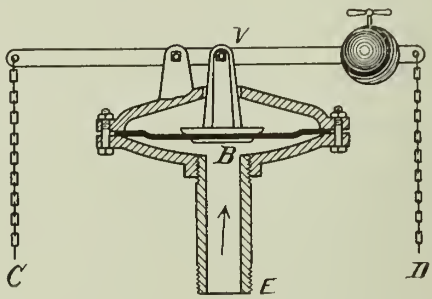


Fig. 50—Cross section of damper regulator for steam boiler.

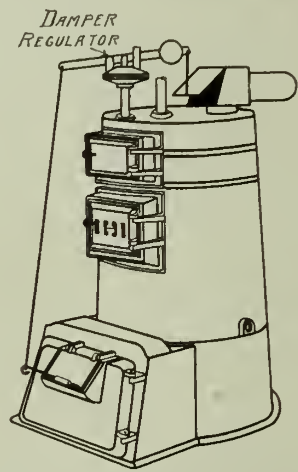


Fig. 51—Steam boiler for house heating, with the damper regulator in place, attached to the dampers.

diaphragm lowers the lever and the dampers are restored to their original position. The same movements are repeated with each rise and fall of the steam pressure.

Damper Regulators for Hot-Water Furnaces: The damper regulator for a hot-water boiler, automatically controls the dampers of the furnace so as to keep the water of the boiler approximately at a constant temperature. The regulator

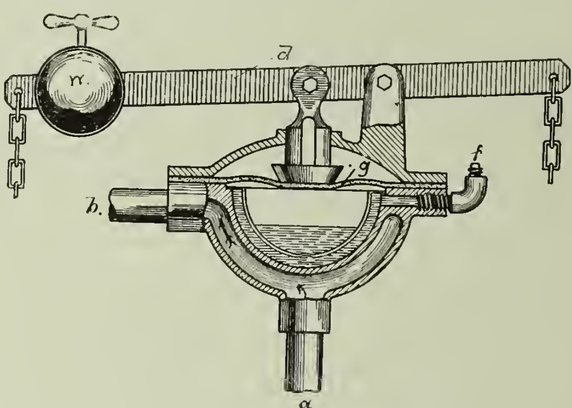


Fig. 52—Damper regulator for hot-water boiler.

is shown in Figure 52. The ends of the lever are connected to the direct draft and check draft dampers, as in the case of the damper regulator for the steam plant. A cross section of the working parts shows the details of construction. The lever *d* is operated by a diaphragm g, which tightly covers a brass bowl, containing a mixture of alcohol and water, of such proportions as will produce a vapor pressure at the desired temperature, say 200 degrees. The hot water from the boiler passes through

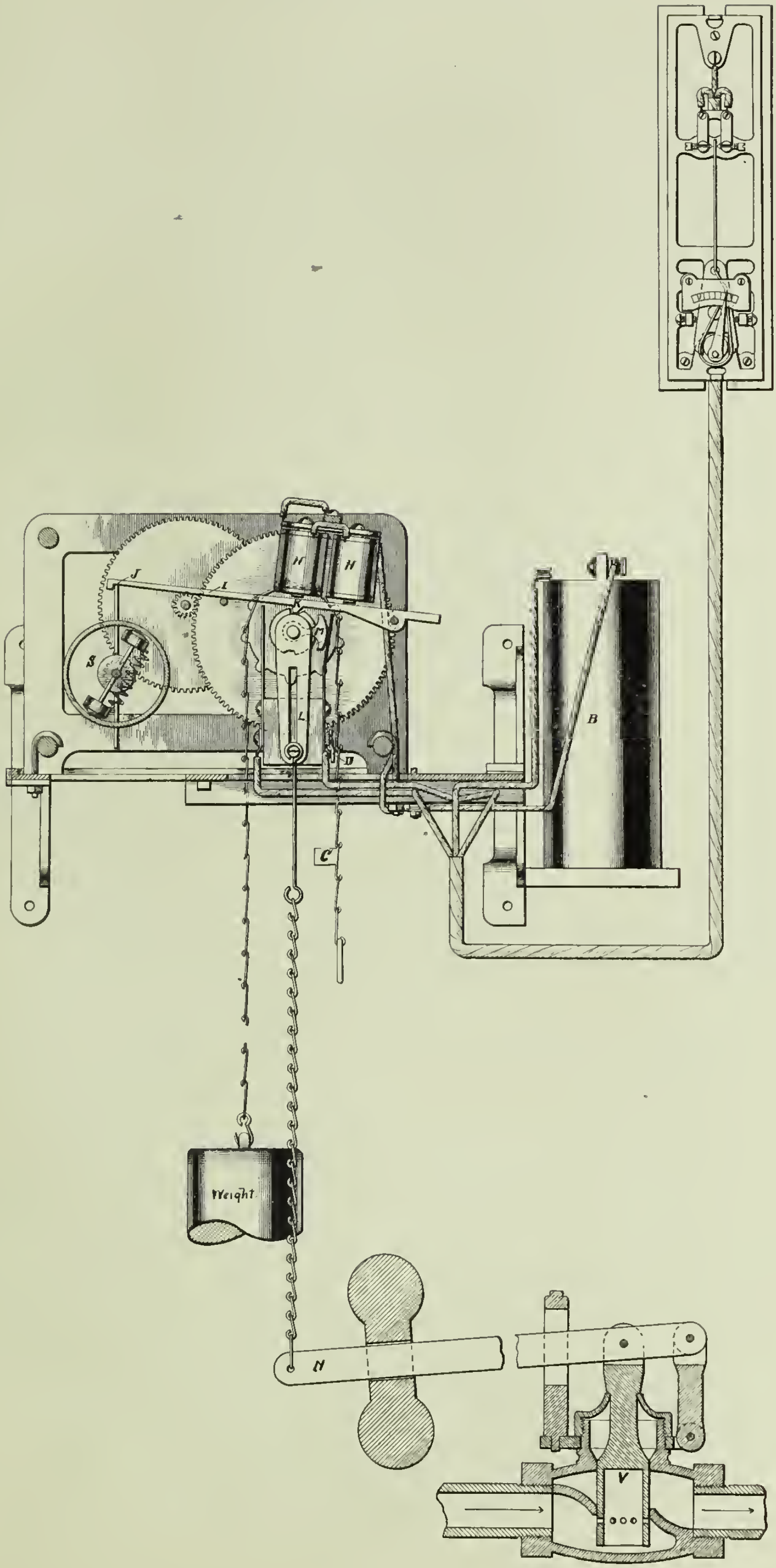


Fig. 53—Thermostat complete with the regulator, hattery and motor attached to a steam supply valve.

the valve, entering at a and leaving at b. When the water reaches the desired temperature, the contained liquid vaporizes and a pressure is produced that is sufficient to lift the diaphragm and the lever. The chain attached to the right hand end closes the direct draft damper; at the same time the other end of the lever opens the check draft, and the supply of air to the furnace fire is entirely cut off. As soon as the water has cooled sufficiently, the vapor pressure in the bowl is reduced, allowing the weight W, to depress the diaphragm and the lever is restored to its first position. The weight W, is for adjusting the valve to the desired temperature. The plug f is removed to introduce the liquid into the bowl.

The object of the damper regulator on a hot-water boiler is to govern the fire of the furnace so as to keep the water in the boiler at the desired temperature, so that in case there is a demand for heat at any part of the house, a supply of hot water will always be on hand. It has nothing to do with the regulation of the temperature of the house. The control of the house temperature is the office of the *thermostat.*

THE THERMOSTAT is a mechanical device for automatically regulating temperature. It may be arranged to operate the valve of a single radiator or register and so control the temperature of a room, or as commonly used in the average dwelling, the controller may be placed to govern the temperature of the living room and in so doing keep the furnace in condition to satisfactorily heat the remainder of the house.

Thermostats are made in a variety of forms by different manufacturers but they may be divided into two general classes; the electric and the pneumatic types. The electric thermostat depends on the electric current supplied by a battery as a means of controlling the action of the motor which in turn operates the furnace dampers so as to maintain a constant heat supply. The pneumatic thermostat regulates the supply of heat by means of pneumatic valves. It may be used for a furnace in the average dwelling but possesses particular advantages of regulating the temperature in large buildings.

Figure 53 illustrates one style of electric thermostat that is very generally used for temperature regulation in the average dwelling. It consists of three distinct parts —the controller, the electric battery and the motor. In the drawing the motor is shown connected with a steam valve, such as may be used for furnishing steam for a series of radiators. It may with equal facility be attached to the dampers of a furnace or other heating apparatus.

The controller occupies a place on the wall of the room to be heated and makes electric connections between the battery and the motor. Whenever the temperature varies from the required degree, a change of electric contact in the controller starts the motor, and the radiator valve or the furnace drafts are opened or closed as occasion requires.

The controller appears in Figure 54 as commonly seen in use. The upper part carries a thermometer and the pointer A indicates the temperature to be maintained in the room. The middle division indicates 70 degrees F. Each division to the right of the middle point raises the temperature 5 degrees. Each division to the left lowers the temperature a like amount.

In addition to the ordinary type this controller is furnished with a time attachment by means of which the controller may permit the temperature of the room to fall to any desired degree at night and raise it again in the morning at the time for which it is set.

This is accomplished by a little alarm clock shown at the bottom of the controller in Figure 54. The indicator B is arranged to correspond with the indicator A; the middle point representing 70 degrees F. To set the time attachment, the alarm is wound and set as in any alarm clock, one-half hour earlier than the desired time for rising. The indicator B is set for the day temperature and A is set for the temperature desired during the night. At the appointed time the alarm moves the indicator A to the desired point for the day and the controller raises the temperature accordingly.

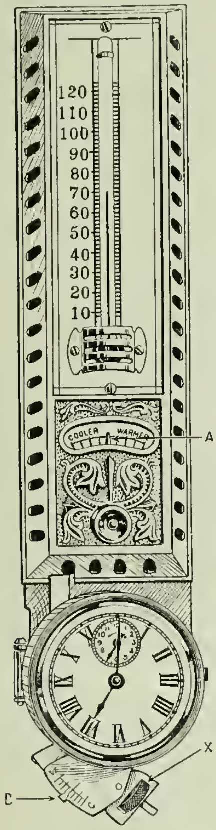


Fig. 54—Front view of the thermostatic regulator with an automatic time attachment.

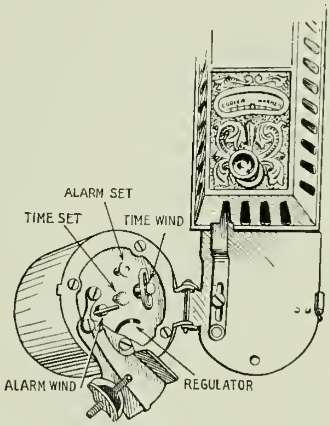


Fig. 54-A—Details of the automatic time attachment.

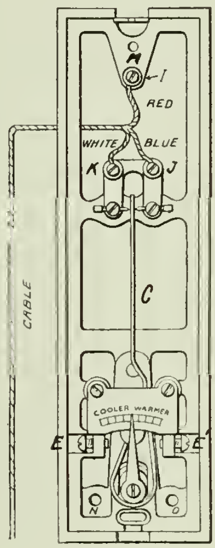


Fig. 55—Details of construction and electric connections of the thermostatic regulator.

Figure 55 shows the mechanism that is exposed to view when the cover of the controller is removed. The bent strip C is the part that is influenced by the change of temperature. It is made of two thin strips of metal, one of brass and the other of steel. The two strips are soldered firmly together. Any change in temperature will affect the strip and cause it to bend and touch the contact point—K or J. The cause of the bending of the strip is due to the unequal expansion of the brass and steel due to the change of temperature. Brass expands 2.4 times as much as steel with the same change of temperature. The amount of bending is sufficient to make an appreciable movement in a small fraction of a degree change. The brass part of C is on the left and since it expands the greater amount, a rising temperature causes

C to come in contact with the point J. When this happens the motor is started and makes one-half cycle. In so doing it shuts off the air supply of the furnace, opens the check draft and at the same time the motor changes the electric contact from J to K. When the temperature begins to fall, the brass contracts at the same ratio to the steel as it expands during the rising temperature and as a consequence the bar bends to the left. When the strip touches the point K the motor again makes one-half circle, admitting air once more to the furnace, closes the check draft and shifts the electric contact back to K. When properly started the thermostat will regulate the temperature within a degree, if so desired.

THE THERMOSTAT MOTOR: The thermostat motor automatically opens and closes the furnace dampers or the valve that admits steam to the radiators as heat is demanded by the controller.

The motor, as shown in Figure 53, consists of a system of gears and a brake S, which regulates the speed, a cam M, and armature I, for starting and stopping the motor, and the electromagnet H-H which operates the bar I. Two lever arms L, one in front and the other at the back of the motor furnish means for attachment to the valve or furnace dampers. An emergency switch at D is shown in detail in Figure 56. The battery B furnishes the current which energizes the magnets and an iron weight supplies the motive power for the motor.

The description of the operation of the motor applies to the steam valve shown in Figure 53. The same motor might be used for opening and closing of the dampers of the furnace in any kind of heat supply. The method of communicating the motion of the motor arms to the dampers of the furnace will be described later.

Suppose that the valve for admitting steam to the radiators, as that in Figure 53, is closed and that the temperature of the house is falling. The strip C of the thermostat controller is moving toward J. When contact is made, the current from the battery B energizes the magnets H-H and the bar I is lifted. As the bar I is raised the catch J is released and permits the motor to start. The bar I is held suspended by the cam M until the arm L has made one-half revolution, when the lug K drops into the depression in the cam made to receive it and the catch J engages with the brake and stops the motor.

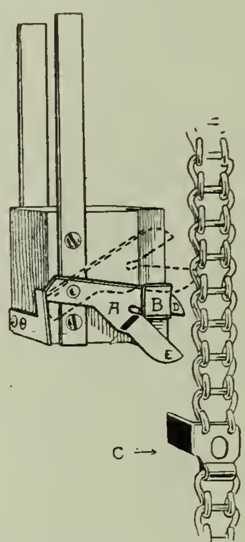


Fig. 56—Autmatic switch for breaking the electric circuit when the thermostat motor has run down.

During this movement the arm L has lifted the valve arm N and the valve admits steam to the radiators, at the same time the contact M has been shifted from the right hand contact to the left, and the electric circuit is ready to be made in the controller at the point K. When the temperaure has fallen a sufficient amount the controller bar C will make contact at K and the motor will again make a half cycle changing the valve back to its original position. This process will be kept up so long as the motor is wound and there is sufficient fuel in the furnace to raise the temperature.

Figure 55 shows the method of connecting the electric wires from the battery to the controller. A three wire cable connects the battery, and makes contacts as indicated at H, K and J. The wires are shown attached to the motor as in Figure 55. A wire is taken from either pole of the battery and attached to one of the ends of the magnet coil. Passing through the magnet the wire is attached to the frame of the motor. This makes the cam M a part of the electric circuit. The other two wires are attached to the brass strips on each side of the arm L. The strips are insulated from the frame. The electric circuit through the magnet is made alternately by contact with the strips at right and left of the arm L.

In case the motor, through neglect, runs down, a safety switch at D disconnects the battery and keeps it from being discharged. This switch is shown in detail in Figure 56. When the weight has reached its limit the piece C on the chain comes in contact with D and lifting it out of contact, breaks the circuit. When the motor is again wound C engages with E and restores the contact. The switch is so arranged that when open, the valve will always be closed.

COMBINED THERMOSTAT AND DAMPER REGULATOR: It is evident that, in heating a house by steam, the *damper regulator* governs only the steam pressure of the boiler. In the use of a thermostat alone, the regulation is that of the temperature of the rooms only, and has nothing to do with the steam pressure. As an example: Suppose that in cold weather the house is cold and that the gauge of the steam boiler shows no pressure. The desire is to get up steam as soon as possible. In so doing a hot fire is made with a large amount of fuel. As soon as the steam begins to form, the pressure rises rapidly. When the radiators have become hot and the steam is no longer taken away as fast as it is formed, the pressure of the steam in the boiler keeps on rising. The thermostat will not close the furnace dampers until the temperature of the rooms is normal. This may require so great a length of time as to produce a great excess of steam that cannot be used at the time and the pressure will be relieved by the safety valve. This may not be dangerous but it is disagreeable. To prevent the safety valve from blowing except in case of emergency, a combined thermostat and draft regulator is used. In such a combination, the draft regulator closes the draft as soon as the pressure reaches the desired point, after which the thermostat does the regulating according to the demand for heat.

In Figure 2 is shown such a combination attached to a boiler. The cord from the regulator instead of extending directly to the direct draft damper, passes over the pulley P and connects to the thermostat cord. The regulator may now close the damper to suit the steam pressure, but after the temperature in the rooms is normal, the amount of heat necessary to maintain the desired degree is regulated entirely by the thermostat which opens and closes the dampers regardless of the position of the damper regulator.

If occasion should require but a very slight amount of steam to keep the house at the desired temperature the thermostat will govern the drafts aright. If the steam pressure is in danger of becoming excessive, the damper regulator will govern the drafts.

THERMOSTAT MOTOR CONNECTIONS: The arrangement of cords and pulleys used for attaching the thermostat motor to the furnace dampers will depend very much on local conditions. The motor can be placed in any convenient position so that the connecting cords will act most directly. The motor opens and closes the direct draft and check draft in accordance with the demand for heat. The connections for all kinds of furnaces are made in much the same manner. The pulleys supplied with the motor are placed to work as freely, and the cords to pull as directly as possible.

In Figure 57 the motor is connected with a hot-air furnace. The cord D is attached to the front arm of the motor and connects with the direct draft damper F. The cord C connects the rear arm of the motor with the check-draft damper at E. In the position of the dampers shown, the direct draft damper is closed and the air

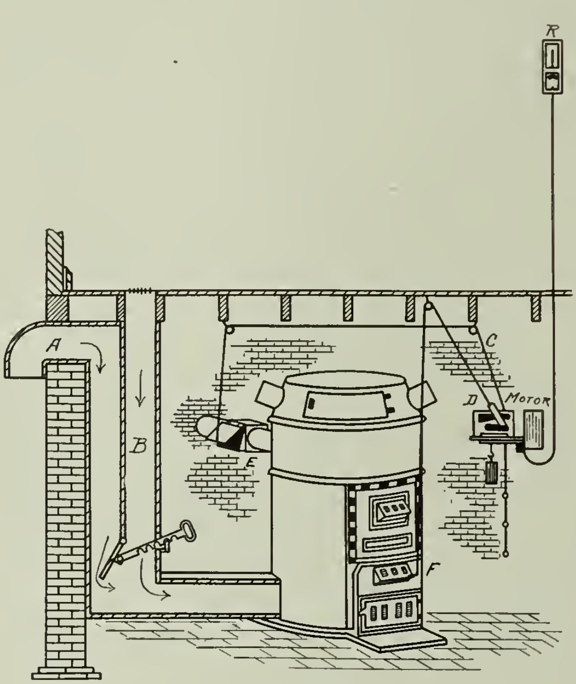


Fig. 57—Thermostat motor connected with the dampers of a hot-air furnace.

is entering the chimney through the check draft E. While this damper is open there is very little induced draft to supply the fire with air that might leak through the crevices around the ash-pit door, but the gases from the furnace are completely carried away to the chimney by the air entering at E.

In Figures 3, 6, 8, 34, etc., the same motor is connected with the furnaces of various other systems of heating. The object is the same in all; when less heat is required, the air supply is cut off and the furnace fire subsides; when more heat is demanded the air is again admitted to produce greater combustion. The check draft is an important feature as it checks the flow of air through the furnace regardless of the position of the direct draft damper. Even should the direct draft be left open, the check draft when open would destroy in a great measure the supply of air entering the furnace.

CHAPTER V
Management of Heating Plants

The following instructions on the care and management of Steam and Hot-water heating plants is printed with permission of the American Radiator Company. They were prepared as a guide to the successful operation of the Ideal heating plants but apply with equal force to other plants of a similar character.

GENERAL ADVICE: No set rules can be given for caring for every boiler alike—chimney flues are not alike—some have strong draft, some are average and some are weak. There is much more more difference in the heat making qualities of coal than is commonly known, and it is important that the right size coal for the draft be used. These rules apply to most all fuels. A little trying of this way or that way of leaving the dampers (when regulators are not used) often discovers the better way. It is well to vary from the rules a little if any of them do not seem to bring about the best result.

With good, average chimney flue draft and the right kind of fuel, these rules will govern the large majority of cases.

THE ECONOMY OF GOOD DRAFT: In many cases a boiler with sluggish draft will burn more coal than a boiler with good draft. In the first case the fuel may be said to "rot"—in lacking air supply the gases pass off unburned. The "nagging" which a boiler has to take under these conditions increases the waste of fuel. A boiler under sharp, strong draft maintains a clear intense fire and burns the gases—getting the larger amount of heat from the coal.

GENERAL FIRING RULES: 1. Put but little coal on a low fire.

2. When adding coal to the boiler, open the smoke-pipe damper (inside the smoke-pipe) and close the cold-air check damper. This will make a draft through the feed doorway inward and prevent the escape of dust or gas into the cellar when the feed door is open to take fuel. Put these parts back to their regular places after feeding.

3. When it can be done, in feeding a large amount of coal (as for night) leave a part of the fire or flame exposed, so that the gases may be burned as they arise.

4. When a regulator is not used, learn to use the dampers correctly and according to the force of the chimney draft. Learn to use cold air check-damper. Often, when closing the ash-pit draft damper does not check the fire enough, opening the cold-air check-damper will check it about right. Increasing or lessening the pressure of a steam boiler must be done by changing the weight on the regulator bar.

5. Carry a deep fire or a high fire; let the live coals come up to the feed door—even in mild weather when from four to six inches of ashes stand on the grate.

6. In severe weather give the heater the most careful attention the last thing at night.

7. Do not overshake or poke the fire in mild weather; once in a while shake enough to give place for a little more fuel.

8. Do not let ashes bank up under the grate in ash-pit. Grate bars are very hardy, but it is possible to warp them with carelessness. Taking up the ashes once a day is the best rule, even if but little has fallen into the pit.

9. Keep the boiler surfaces and flues clean; a crust of soot one-fourth inch in thickness causes the boiler to require half as much more fuel than when the surfaces are clean.

10. If convenient, have a water hose to spray the ashes when cleaning out the pit.

11. Attend the boiler from two to four times per day. In mild weather, running with a checked fire, morning and night is usually often enough. In severe weather, once in early morning, again at mid-day, again at five or six o'clock and finally thorough attention at from nine to eleven o'clock in the evening.

12. If, through burning poor coal, the fire pot gets full of ashes, or slate and clinkers massed together, the quickest way to get a good active fire is to dump the grate and then build a new fire—from the kindling up.

13. If a *hard clinker* lodges between the grate bars, do not force the shaking, but first dislodge the mass with a poker or slicing bar. Then the grate will operate without damage.

WEATHER AND TIME OF DAY: In *severe weather* keep the fire-pot full of coal, and run the heater by the dampers or regulator (if one is used). Thoroughly clean the grate twice a day. Let the top of the fire in front be level with the feed door sill. Bank up the coal higher to the rear.

In *moderate weather* there should be from two to six inches of ashes between the live coal and the grate. As the weather grows colder keep the grate and the fire-pot a little cleaner—sometimes it helps to run the poker or slicing bar over it through the clinker door. With some fuels this is never necessary.

NIGHT FIRING: In very *cold weather*, when the house should be kept warm all night, clean the grate well at a late hour—the last thing. Clear the bottom of the fire-pot of all ashes and clinkers so that the grate is covered with clear burning, red-hot coals, then fill the pot full of fuel. If possible, leave some of the flame exposed to burn the gases. Leave the drafts on long enough to burn off some of the gas, then check the heater for the night. Thus there is plenty of coal to burn during the night and some on which to commence early in the morning. Some drafts do not make it necessary to leave the dampers on to burn off the gas after feeding.

With the ash-pit draft damper closed and the cold-air check damper open at night, but part of the coal is burned and there is much of it not burned in the morning. So, by reversing the dampers in the early morning the fire starts up quickly and often the house may be well warmed before any coal is put into the fire pot.

Some boilers are run the other way—a very poor way. If the grate is cleared off in very cold weather and some coal added at five or six o'clock in the afternoon, by eleven o'clock at night nearly one-half of the coal is burned and the grate is covered over with a mess of ashes and clinkers. If no more coal is added during the evening, by morning about all the coal is burned out. So, with little or no coal remaining, shaking the grate nearly puts the fire out, and then putting fresh coal on a low fire causes the water to chill and the next thing is a house, which was cold all night, growing colder.

Often in cold weather with this poor way of night firing, it takes one or more hours of forced firing to warm the house in the morning, and all the coal saved the night before is more than used to get the house or building "heated up"—while the people who should be comfortable have to get up, bathe and take breakfast in chilly rooms. At no time in the day is heat more wanted than about the time of getting up and starting the day. A fire well cared for late in the evening makes a warm house all night. And so it follows that it is much easier to add a little more heat in the morning. And surely less coal is burned, for the forcing of a fire part of the time often overheats, and wastes coal.

FIRST DAY FIRING: In the morning of *moderate winter weather*, with the ash-pit draft damper open, before adding any coal allow the fire to brighten up if it seems to be low; then (for such conditions) spread over a thin layer of fresh coal and set the drafts for a brisk fire. After the new fire is well started add as much coal as may be necessary to last until next firing. Do not shake much if any—just enough to give space for more coal. Then by setting the regulator (if one is used), or, by closing the ash-pit draft damper and opening the cold air check damper a little, the boiler should keep up its work until the next firing time.

In *severe weather*, if the boiler has been attended to at night as directed in the section on "Night Firing," the drafts can be turned on and the boiler run for half an hour before adding coal. Or, if more convenient to give it immediate attention, the grate can be thoroughly shaken and enough coal added to last until mid-day. Often the cold-air check damper will need to be entirely closed and the ash-pit draft damper partly open if the heater is a water boiler. If a steam boiler, the regulator should then be set to maintain the number of pounds of pressure wanted and so left.

OTHER DAY FIRING: In *severe weather* more coal should be added about noon, sometimes the draft may be left on for a few minutes and then checked. And in such weather it is often well to give the boiler further attention at five or six o'clock. In severest weather the boiler should not be attended more than four times a day; and generally not less than three times.

Often much coal is wasted by "nagging" the fire—poking, shaking and feeding it until it becomes "dyspeptic." A sure cure is a little common sense in regular feeding, etc.

ECONOMY AND FUELS: In running many boilers for *moderate weather* better results follow if the grate is not shaken too much or too often. Sometimes in *moderate* weather a body of ashes on the grate checks the fire and there is enough heat without a useless burning of fuel. Many houses are overheated in *moderate* weather and too much coal burned by running the boiler as for zero weather.

So we repeat—*it is not wise to overshake or overfeed a boiler in moderate weather.* The fire should be in such shape that if a change comes at night there is a basis for a good fire to start on. When the grate is shaken but once during the twenty-four hours (during *moderate* weather) late at night is the best time.

When one stops to think that heating is needed during about seven months out of the year, and that *a greater portion of this time is usually moderate weather* when a very little heat is needed, it must be seen that the science of running the heater to save coal is to apply common sense rules of limiting the feeding and the attention in such periods. In *severe weather* we believe in giving the boiler a liberal quantity of fuel regularly and at the right time. The time to save coal is when there is no need for burning it. This is where a great many people make errors in running the boiler—in forgetting to "let up" on the shaking and feeding in moderate weather.

With some drafts and for boilers using hard coal or coke, good economical results often are secured by opening the feed door a little when it is desired to check the fire in moderate weather. This depends on the draft.

For Burning Soft Coal: Some types of boilers are made to burn soft coal with economy, with least work. Some types are made specially to burn the meaner grades of soft coal. Firing to prevent smoke is a source of economy and these ways of running should be followed—specially with large sectional boilers.

There are two types of soft coal, viz.: The free burning coal, which breaks apart when burning, allowing the gases to freely escape; and the fusing-coking coal, which, when burning, first fuses into a solid burning mass with a hard crust over the top, slowly coking as it burns. The latter kind is most valuable for house-heating boilers because the gases are more thoroughly consumed. The fusing-coking coal is worth about 20 per cent more for this purpose than the free-burning coal.

The gases should be allowed to pass off from the coal *slowly*. Leave air inlet on the feed door open if draft permits. If possible, use uniform sizes of coal. Avoid using coal having too much dust—the "run of the mine" may be lower in price but its heat-making value is also low.

For the purpose of slow burning of soft coal, it is well in feeding at night to let the fire burn up freely so that the coals are very live with heat. Then fill in enough coal to last all night—leaving some of the live coals uncovered if possible. With large sectional boilers this exposure should be at the rear of the fire so that the flame will pass over the live coals. Thus the gases coming off from the fresh coal are burned and a larger amount of the full heat-producing value of soft coal is made use of and with less smoke.

After a boiler is so fed, the dampers (unless an automatic regulator is used) should be left about as follows:

Ash-pit draft damper open a little or closed, as draft may require.

Cold-air check damper open about one-eighth to one-third distance of the opening.

Smoke-pipe damper about one-half closed.

A little experiment with the draft will usually tell the operator the best way of leaving these dampers.

It will be found in the morning that the entire charge of coal is well burned or partly coked.

The coked fuel, or that which sticks together in a mass, should be broken up by the poker and more added generally as by rules given in other sections.

It must always be remembered that the soft coals mined in different parts of the country have widely varying heat-making capacities. To obtain satisfactory results brands must be selected which have an established reputation for excelling results in small boilers.

For Burning Coke: It is best to keep the pot *full* of fuel—keeping a large body of coke under a low fire rather than a little fuel under a strong fire.

It must be remembered that coke makes a very "hot fire" because the coke is so free burning. Care should be taken not to leave drafts on too long in boilers not having regulators.

Coke burns best for house heating purposes with less draft than is required for coal, therefore to keep a low fire the ash-pit draft damper should be kept closed, and the smoke-pipe damper almost entirely closed. The regulator (when used) can be set to keep the dampers about as here advised. Coke is practically smokeless and its quick burning character makes a cut-off damper in the smoke pipe (which will stay fixed as it may be set) quite necessary.

It is well to keep a layer of ashes on the grates and when shaking stop before red hot coals come through the grate. The coke then burns more slowly, which increases its effectiveness.

With some drafts it may be well to "bank the fire" at night with coke,—pea coal size. This is a matter of experiment, and depends on the character of the chimney draft.

Fire should be tended regularly—two times a day, or four at the outside.

With an extra strong draft, at night the fuel should be packed down by tamping with the back of a shovel.

With ordinary condition of draft, crushed coke, small egg size, should be used.

Other Rules for Water Boilers: *To fill system*—Open the feed cock when the heater is connected with a city or town water supply; if not, fill by funnel at the expansion tank. Fill until the gauge glass on the expansion tank shows about half full of water. In filling the system see that all air cocks on the radiators are closed. Then beginning with the lower floor, open the air cocks on each radiator, one at a time, until each radiator is filled; then close the air cock and take the next radiators on upper floors until all are filled, after which let the water run until it shows in the gauge glass of the water tank. After the water is heated and in circulation, vent the radiators by opening the air valves as before. Then again allow the water to run into the system until it rises to the proper level in the expansion tank gauge glass.

Always keep the apparatus *full of water* unless the building be vacated during the Winter months, when the water should be drawn off to prevent freezing. *Never draw water off with fire in the heater.*

To draw off water, open the draw-off cock at the lowest point in the system, and then open air cocks on all radiators as fast as the water lowers—beginning with the highest radiator.

Air Vent Valves on Radiators: In order to secure the full benefit of the heating surface of a hot water radiator, the inside of the section must be free of air. When a radiator is "air bound" it means that parts of the sections are filled with air in pockets which remain until the air is allowed to pass off through the vent valve.

Air will gather from time to time at the highest points inside the radiators, especially in those placed in the upper stories of the building. These air accumulations inside cut down the working power of a radiator exactly in proportion as they rob the inside of the casting of proper contact with heated water. Air pockets not only reduce effective heating surface, but they also prevent the circulation of hot water.

Therefore, it is well once in a while to take the little key provided by the heating contractor and open the air valves on radiators to allow the air (if any) to escape. When a radiator does not work as well as usual, open the air valves until the water flows, which indicates that the air has been fully released. Then close the valve.

Valves on Cellar Mains: If cut-off valves have been placed on the main and return pipes in the cellar, see that the valves on one line of main and return pipes (at least) are open when the boiler is under operation. Be sure that the system is open to circulate water through the supply and return pipes before building a fire in the boiler.

End of the Season: At the close of the heating season clean all the fire and flue surfaces of the boiler. Let the water remain in the system during the summer months. No bad results will follow if the system is not refilled more often than once in two or three years. But, generally, it is thought that best results are secured by emptying the system once a year (after fire is out) and refilling with fresh water.

It is a very good idea to take down the smoke-pipe in the spring, thoroughly clean and put it back in place. Leave all doors open on the boiler in the summer time.

Other Rules for Steam Boilers: *To Fill Boiler*—Open the feed cock when the heater is connected with city or town water supply; if not, fill through the funnel. Let the water run until the gauge glass shows about half full of water.

In the first filling, after the water has boiled, get up a pressure of at least ten pounds, draw the fire and blow off the boiler under pressure through draw-off cock to remove oil and sediment, after which refill with fresh water to the water line. This is best done usually by the steam-fitter.

The damper regulator will control the pressure of steam, closing the damper when the pressure is raised beyond the desired point and opening the damper when the pressure falls below that point. By removing the weight on the lever, different degrees of pressure can be kept up. The regulator should be allowed to control the drafts without interference.

Examine the water glass often to see that the *water line* is at the proper height. If lower than normal open the supply pipe until the water runs in and stands at the proper level. It is best when no water stands in the glass, nor shows at the bottom of the try-cock, to quickly dump the grate and do not put water into the boiler again until it is cooled off.

If there is one or more shut-off valves on the main or return pipes, before starting a fire see that one line of piping at least (main and return) is open to circulate the steam.

To Control Radiators: When it is desired to shut off steam from any radiator (if the regular radiator valves are used), close the valve *tight*, and when it is turned on see that the valve is *wide open*. A valve partly turned off will cause the radiator to fill with water. This rule applies only to one-pipe heating systems.

The Air Valves: If little keyed air valves (sometimes called "pet cocks") are used, follow generally the same directions as outlined for hot water radiators on page 38,—only, of course, in releasing the air from the radiator open the valve with the key provided and close it just as soon as the steam unmixed with air comes through the nose of the valve.

If "automatic" air valves are used they must be carefully adjusted by the steam-fitter and then left to operate without undue interference.

End of the Season: At the close of the heating season fill the steam boiler with water to the safety valve and let it thus stand through the Summer.

Also thoroughly clean all the fire and flue surfaces of the boiler and at the opening of the next season withdraw the water and refill with fresh water to the water line, starting the boiler as before.

It is advisable to have a competent steam-fitter blow-off the boiler under pressure and thus give the inside a thorough cleaning when the boiler is first set up and ready for fire.

A low pressure boiler, using good water, rarely needs blowing off after it is once cleaned at time of setting up.

THE RIGHT CHIMNEY FLUE.

The area of the flue should never be less than 8 inches in diameter if round, or 8 x 8 inches if square—unless for a very small heating boiler or tank heater. 9 or 10 inches round, or 8 x 12 rectangular is a good average size. The flue should generally have a little more area than that of the connecting smoke pipes.

Draft force depends very much on the height of the flue.

The chimney top should run above the highest part of the roof and should be so located with reference to any higher buildings nearby that the prevailing wind currents will not form eddies which will force the air downward in the shaft. Often a shifting cowl which will always turn the outlet away from the source of adverse currents will promote better draft.

The flue should run as nearly straight up from the base to the top outlet as possible. It should have no other openings into it but the boiler smoke-pipe. Sharp bends and off-sets in the flue will often reduce the area and choke the draft. The flue must be free of any feature which prevents a free area for the passage of smoke. The outlet must not be capped with any device which makes the area of the outlet less than the area of the flue.

The best form of flue is a round tile—in such there is less friction than in the square form and the spiral ascent of the draft moves in the easiest and most natural manner.

If the flue is made of brick only, the stack should be at least two four-inch courses in thickness.

If there is a soot pocket in the flue below the smoke pipe opening, the clean-out door should always be closed. If this soot pocket has other openings in it,—from fireplaces or other connections, such arrangements are very liable to check the draft and prevent best action in the boiler.

The smoke-pipe should not extend into the flue beyond the inside surface of the flue, otherwise the end of the pipe cuts down the area of the flue and injures its drawing capacity.

The inside of a flue should be smooth (pointed or plastered). When the courses are laid with the mortar bulging out from the joints the friction within the flue is very much increased. Often a troublesome flue is corrected by lowering some sharp edged weight by a rope which should be worked against the sides of the flue until the clogging is scraped off.

A new chimney when "green" will not have a good drawing capacity. Short use dries out the mortar and better results follow.

CHAPTER VI

Plumbing

The term plumbing is usually understood to cover all piping and fixtures that carry water into the house and remove the waste material in the form of sewage. It does not include the pipes of the heating system. Although the work of installing heating plants is frequently done by plumbers, steam fitting and plumbing are two distinct trades.

In the process of building a house the rough plumbing is put into place as soon as the structure is enclosed and the rough floors are laid. The rough plumbing includes the soil pipe, into which the waste pipes from the various fixtures empty, and those pipes which must ocupy a position inside the partition walls and beneath the floors.

The connections here described are for a city dwelling and apply to the custom of local conditions. The same system might be used for a country residence except in regard to the water supply and method of sewage disposal. Plants of this type are discussed in the chapter on *Septic tanks*.

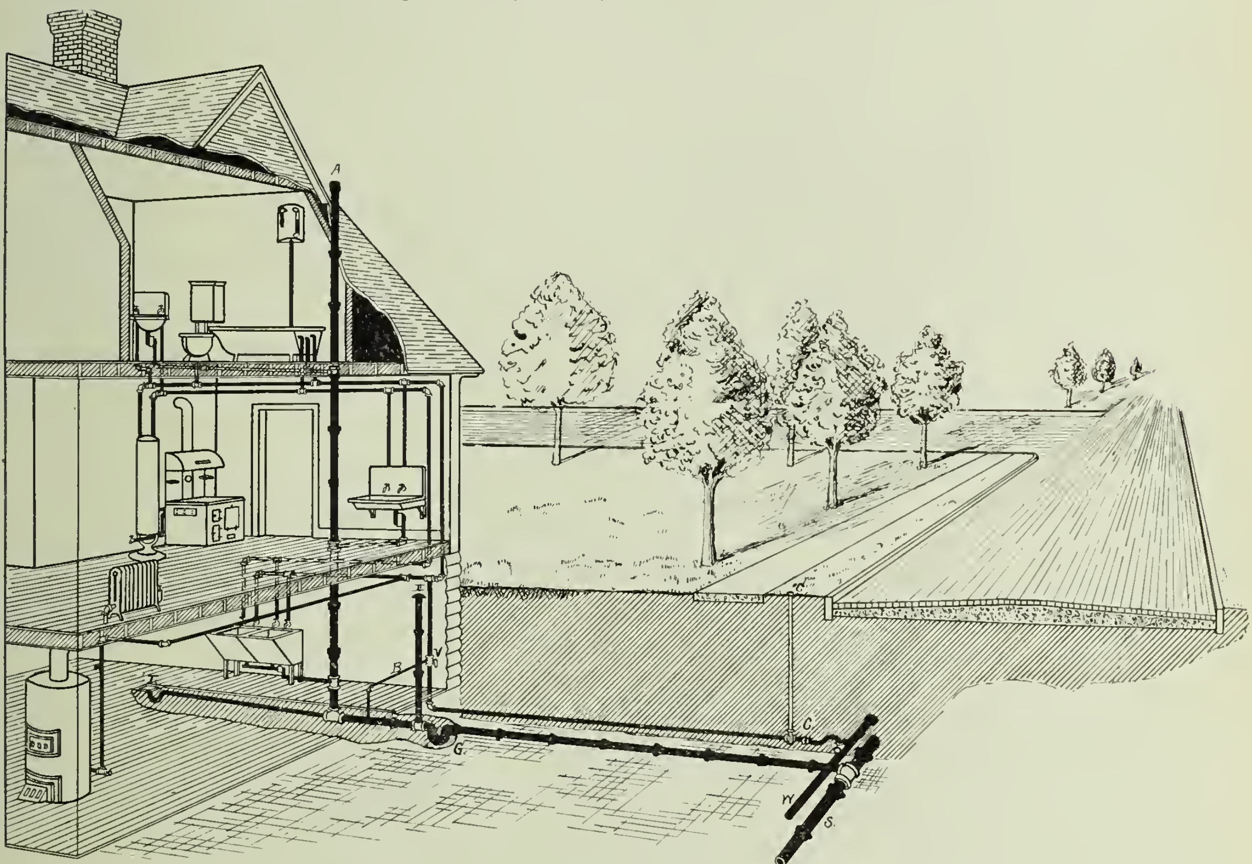


Fig. **58**—Cross-section of a city street showing the watermain and sewer pipe with their connections to a dwelling.

Figure 58 shows a cross section of the street, exposing the sewer S, the water main W, and the connections with the house. The side of the house has been removed to permit a view of the water and sewer pipes, connecting with the bath room, kitchen, laundry and other basement fixtures.

The lateral sewer or house-drain which connects the house with the street sewer S, is provided with a trap G, located, in this case, just outside the basement wall. The house-drain is made of vitrified tile, laid so as to grade into the street sewer with the greatest possible pitch. The sections are laid as true as conditions will permit and the joints are all carefully filled with cement mortar to prevent leakage. The object of the trap G, is to prevent sewer-gas from entering the house from the main sewer. The trap prevents the gas from passing because the water in the bend of the trap forms a water seal, beyond which the polluted air from the sewer cannot travel.

Next inside the trap is the vent pipe E, that extends to the surface of the ground. In this case it is just outside the basement wall. The top is covered with a metal cap. Another arrangement often made to accomplish the same purpose is shown in Figures 61, and 62, where a piece of soil pipe in the form of a bend is made to take the place of the cap. Inside the basement and extending up, through the partition walls to the roof is the *waste-stack* or soil pipe A. This pipe as is explained in detail later, is made of cast-iron and is put together with calked lead joints. The top of the stack at the point where it passes through the roof is shown in Figure 59. In

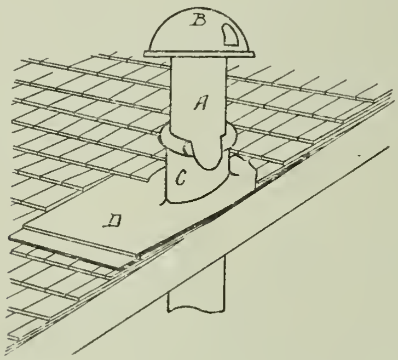


Fig. 59—Detail of soil pipe connection.

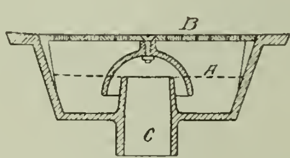


Fig. 60—Cross-section of cellar drain.

extending through the roof the pipe A, must make a water tight joint to prevent water from leaking through. This is accomplished by means of the metal plate D, which is set under the shingles and the piece C, that is soldered to D. The joint between C, and A, is best made with lead the same as the other joints of the stack. In the case of very high stacks, the bottom should be supported by a pier or iron pipe rest. Besides being supported at the base the stack should be secured to the side walls or floor beams at each floor. This is to keep the pipe from moving out of place and the consequent opening of joints.

All of the waste pipes from the bath room, kitchen and basement drain into the waste stack. The cellar drain for draining the basement is shown at T in Figure 58. It also appears in detail in Figure 60. The plate B, in the latter figure is set flush to the surface of a depression in the floor that serves as a collecting point for water. The floor is constructed to drain toward this point. The plate is perforated to let the water through and is generally hinged so that in case of stoppage the cover may be raised. The bell shaped piece under the cover, surrounds the piece C, to form a water seal when the level of the water is at A. In addition to this water seal there is generally a trap between the drain and the sewer as shown in the drawing.

The method of connecting the bath-room waste-pipes with the stack is shown in Figure 99, and will be described later. All of the sewage of the house is emptied into the stack by the most direct route, and from the stack it is conducted as directly as possible into the sewer. From the drawing it will be seen that all openings to the sewer are sealed in two separate places, once at the outlet to prevent the air from the street sewer entering the house drain G, and again at each opening to prevent escape of the sewer-gas from the drain into the house.

The openings at E, and A, at each end of the stack permit a constant circulation of air for ventilation. The length of the stack and its location causes it to act as a chimney and the draught produced, takes the air in at E, and discharge it at the top. In large houses there is sometimes added a vent stack to produce further ventilation, but in the average dwelling the arrangement here shown covers the common practice.

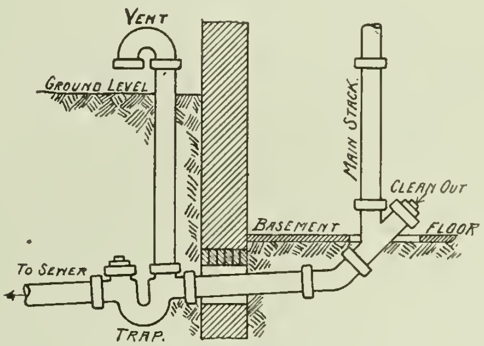


Fig. 62—House drain with outside vent, and running trap placed outside the basement wall.

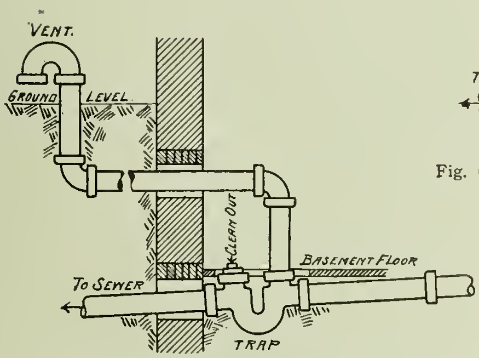


Fig. 61—House drain with outside vent, and running trap placed inside the basement wall.

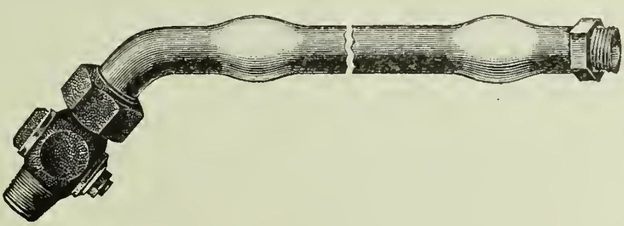


Fig. 63—Corporation cock with lead connecting pipe,

In figures 61, and 62, are shown in detail two methods of arranging the sewer connections in the basement to permit of the removal of obstructions in case the pipes at any time become stopped. The trap, vent, etc., are easily recognized. With the arrangement as shown in figure 62, the cleanout is so placed as to give access to the inside of the pipe. Should an accumulation or obstruction of any kind become lodged in the pipe, the stop in the cleanout is removed and a flexible metal rod is used to remove the stoppage. The trap outside the wall has an opening through which the obstruction may be reached in case it cannot be removed from the first cleanout. The disadvantage in using the outside trap, as here shown, is that it can only be reached by excavation.

Figure 61, shows another common method of installation. Here the trap is placed inside the basement wall. This gives an easier means of opening the trap than figure 62 affords and accomplishes the same purpose. The connections with the stack are the same as in Figure 62. Obstructions in the sewer pipe are most likely to become lodged in the trap and for this reason the trap should occupy a position that is reasonably easy of access.

The outside trap as described above is quite generally installed in buildings of all kinds, but its use is by no means universal. In some communities it is not used at all, and many plumbers consider it only an added means of causing stoppage and an extra expense to install.

The object of the outside trap is to keep the air of the street sewer from entering the house drain. It is at once inferred that the air of the street sewer is more dangerous than that of the house drain. The street sewers, however, are ventilated at each street corner and at each manhole. There cannot then be much difference in the air of the two places. The traps on the fixtures that prevent sewer gas from entering the house would be just as efficient if the outside trap did not exist.

While the methods shown in figures 61 and 62 are considered good practice, there is considerable objection to the vent being placed near the dwelling, because of the sewer-gas that is forced out, whenever a sudden discharge of water goes into the drain. Each time a closet is flushed, a large volume of water enters the stack and completely fills the pipe. When this occurs, the descending water forces out the air of the pipe ahead of it, and a gush of offensive air filled with sewer gases is forced out of the vent. It is evident that such a vent, located near an open window or where it will reach the nostrils of the inhabitants is a thing not greatly to be desired.

Outside traps when placed near the surface sometimes freeze. The circulation of air through the vent is occasionally sufficient in cold weather to freeze the water and stop the trap.

WATER SUPPLY: The water supply taken from the street main is conducted to the house by the pipe shown in figure 58, at C. This pipe is generally of lead as piping of that metal is the most durable for underground work. Iron used under the same conditions will last only a few years. The connection is made with the water main by use of a *corporation* cock. This is a special style of cock that is shown in figure 63. In the figure the cock is connected with a short piece of lead pipe that is used for making connection with the service pipe in the house.

Located at the left of C, in Figure 58, is the *curb cock*, used for shutting off the water from the city lot. The curb cock, being underground, is reached through an iron tube by means of a wrench attached to a long iron rod. The curb cock has a protective covering in the form of an iron pipe. The lower end of the pipe screws into

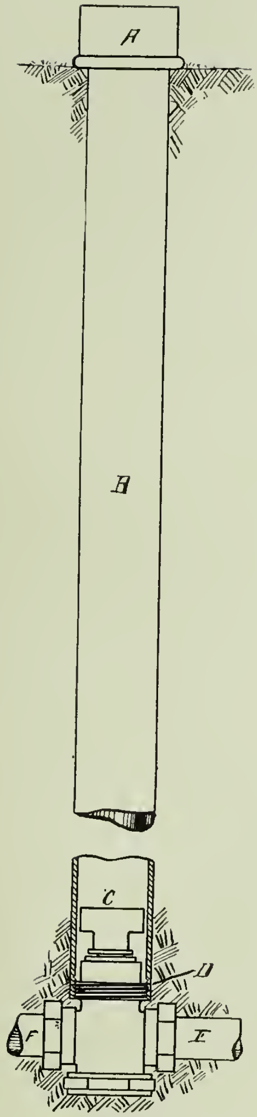


Fig. 64—Curb cock as it appears attached to the service pipe.

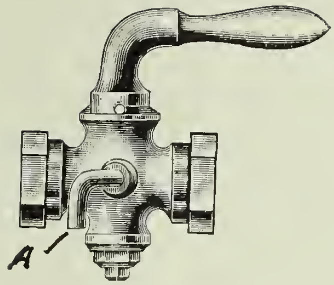


Fig. 65—Stop and drain cock with lever handle.

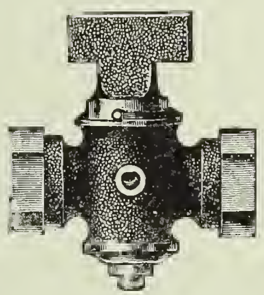


Fig. 66—Stop and drain cock with T handle.

the body of the cock. The top end comes just above the grade line of the curb and is covered with an iron screw cap. The curb cock is shown in detail in figure 64. The pipe B, is fastened to the valve at D, and A is the screw cap. In opening and closing the wrench fits over the part C, of the valve.

On entering the building the supply pipe should be provided with a *stop* and *waste* cock for shutting off the water from the house and draining the pipes that compose the system of circulation. At V, in Figure 58, is indicated a stop and waste cock with the waste pipe B connected with the sewer. This cock is shown in detail in figures 65 and 66. The cock is so made that when closed there is a small opening at A, that allows the water from the system to escape through the waste pipe.

From the water supply, the cold-water pipes may be traced in the drawing directly to each of the fixtures of the house. The hot-water pipe leaves the range boiler at the top and connects with each fixture using hot water, thus making the circuit complete. Details of the piping which provides hot water is described under range-boiler, page 97.

WATER COCKS.

The development of modern plumbing has brought about the use of a great number of household mechanical appliances, that have received trade names little understood by the average person. The lack of distinguishing terms, or language in which to describe plumbing fixtures, often leads to embarrassment, when such articles are to be described to workmen. Common household valves and cocks are so classified by the trade, that mistakes are often made in their designation, because of a limited knowledge of the use of the various articles. A little consideration of the different classes of fixtures, will make it possible to state to a tradesman the exact article in question.

The term *valve*, is intended to define an appliance that is used to permit, or prevent the passage of a liquid through the opening or port which it guards. The term is so general in its application that there are hundreds of different kinds of valves. Even for a single purpose there are many styles of a given kind.

A *cock* was originally a rotary valve or spigot used for drawing water. Today there are many kinds of cocks that are not rotary in their movement.

It would be impossible in this work to describe in detail all of the kinds of cocks and valves used in household plumbing. It will, therefore, be the aim to confine attention to one article of a type and to choose such examples as are in general use and that are good representatives of their classes.

Bibb Cocks. On the kitchen sink, the water faucets, such as those shown in figure 66, are termed bibb cocks by the plumber. If the nozzle is plain, it is a *plain bibb*. If the nozzle is threaded so that a hose connection may be attached as in figure 67, it is a *hose bibb*. Bibb cocks are found in three general styles. Compression bibbs, ground-key bibbs, and Fuller bibbs. The compression bibb takes its name from the method of closing the valve. Figure 68 gives an example of its mechanical construction. This is a plain *solder bibb* because the shank A, is to be attached by a solder joint. If the part A, contained a thread to make a screw joint, such as figure 67, it would be a plain, compression, *screw bibb*. Figure 67-a, is another style of com-

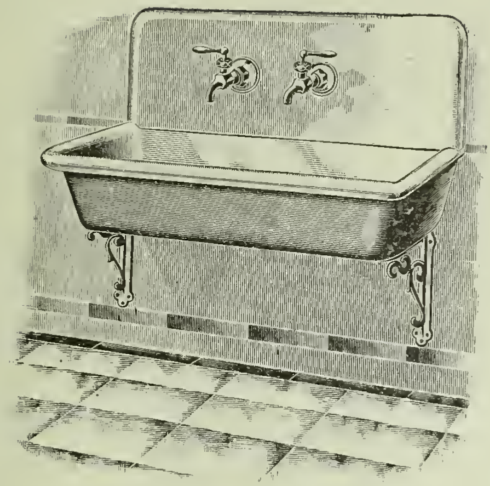


Fig. 66-A—Kitchen sink with Fuller Bibb cocks.

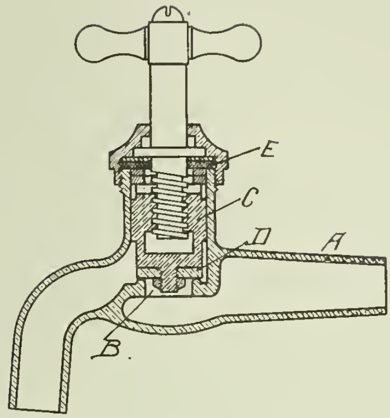


Fig. 68—Cross section of plain compression Bibb Cock for a solder joint.

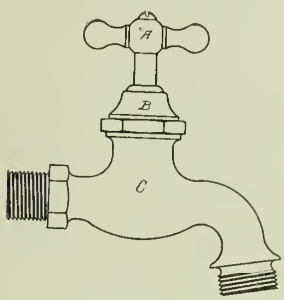


Fig. 67—Compression Hose Bibb.

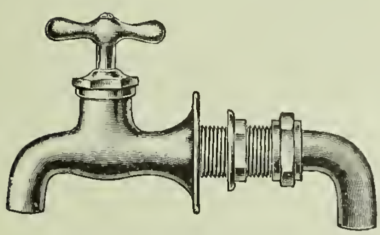


Fig. 67-a.—Compression flange bibb.

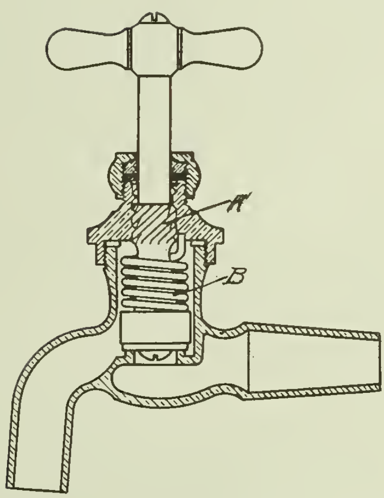


Fig. 69—Cross section of plain self-closing Bibb Cock for lead pipe.

pression bibb cock, largely used on sinks; this cock, being finished with a flange, is a *compression flange bibb.*

Figure 68, shows quite clearly the mechanical arrangement of the compression cock; when the handle is turned the nut C, lifts the valve from its seat B, allowing the water to escape. The piece D, is generally made of composition rubber that may be bought at the dealers for a trifling amount but it may be replaced temporarily with a piece of leather. The part E, is packing, to keep the water from leaking out around the stem. The packing may be obtained from the dealer especially for the purpose or it may be made of a disc of sheet rubber. In fact, anything that can be put into the space will answer the purpose temporarily. The valve is closed by compression, hence the name compression cock. All cocks made to open and close in the same manner are compression cocks.

SELF-CLOSING BIBBS. In figure 69, is one example of the many styles of self-closing bibb cocks. When the handle of this cock is turned the steep pitched screw A, opens the valve and at the same time compresses the spiral spring B, when the handle is released the valve is pressed back on its seat by the spring. Self-closing cocks are used to prevent the waste of water at drinking fountains, wash basins and other places where the water is apt to be left running through carelessness.

LEVER HANDLE BIBBS. Figure 70 is an example of the *lever handle, ground-key* bibb cock. The key is the piece A, which is tapered and forms a ground joint with the part B. The cock takes its name from the form of the handle. The term ground-key means that the key has been ground into place with emery dust. This cock is kept from leaking by adjustment of the screw C.

FULLER COCKS. These cocks take their name from their inventor. They are made to suit every condition for which water cocks are used. Their universal use attests to their utility and excellence in service. Figure 71 shows the principle on which all Fuller cocks work. The varying conditions under which the cocks are used requires a great many forms, but the working principle is the same in all. In these cocks, the valve is a rubber plug or ball that is drawn into the opening by an eccentric piece attached to the handle. The piece D, in the drawing is the rubber plug that is drawn against the opening by the crank B, which is worked by the lever handle A. This cock may be repaired, in case it leaks, by unscrewing it at the joint nearest the plug. A wrench and a pair of pliers are all the tools required. The pieces D, must be obtained from the dealer. The part J, is the packing that keeps the water from leaking out around the stem. The screw cap H, forces a collar I, down on the packnig to keep it water-tight.

The parts for the Fuller cock that may be obtained for repair are shown in detail in figure 72. The ball, which appears in figure 72 at D, is the part that receives the greatest amount of wear. If the cock at any time fails to stop the flow of water, a new ball may be put in place by the aid of a wrench and a pair of pliers. The water being first shut off from the system, the cock is unscrewed and the cap E removed with a pair of pliers. The worn ball is then removed and a new one substituted.

WASH TRAY BIBBS: A special style of cock is made for laundry wash trays in both the Fuller and compression types. Of these the Fuller type is the most convenient as the handle is placed on the side and but one movement is required to open the cock. This style of cock is used on the wash trays shown in figure 83.

Basin Cocks. Water cocks for wash basins are made in two general types, the compression and the Fuller types of cocks. Their mechanism is much the same as for other similar styles adapted to the use for basins. The self-closing cocks used so largely on wash basins are compression cocks. Figure 73 is an example of Fuller basin cock in general use. Compression cocks for the same purpose are shown on the wash basin in figure 90.

Pantry Cocks. In general form, pantry cocks are the same as those used for basins except that the outlet is elongated.

Sill Cocks. As a means of attaching garden hose or lawn sprinklers, sill cocks are placed on the side of the building at any place convenient for their use. Figure 75 illustrates the method of attaching the cock to the water supply. Figure 76 shows in cross section its mechanical arrangement. The part A is screwed into the water supply, and B furnishes the hose attachment. The valve is operated the same as any other compression valve. In figure 75, the cock is shown at A with a garden hose attached. The pipe to which A is attached passes into the basement and connects to the water supply. The stop-cock B is used to shut off the water. When the stop-cock B is closed, A should be opened, so that the pipe will drain. If this is neglected during freezing weather, the pipe is apt to freeze and burst.

Valves. The distinction between a cock and a valve is not at all definite. Custom has determined that in certain places a cock shall stop the flow of a liquid but in another place, perhaps of a similar nature, a valve shall accomplish the same purpose. The chief distinction between a cock and a valve is that of its external form.

In figures 77, 78 and 79, are three examples of valves that are very generally used on pipes carrying any kind of fluid. The valves are shown in cross-section to display the arrangement of the mechanism.

Figure 77 is an example of the common *globe-valve*. The name was originally intended to define a valve the body of which was in the form of a globe. The hand-wheel H, attached to the screw stem S, raises the valve A when desired. The valve makes close contact with the seat C, by means of a composition rubber disc B. The disc B may be renewed when worn out as in the case of the radiator valve already described.

Figure 78 represents an *angle globe-valve*. In general construction it is quite similar to figures 14 and 15, but the valve V, in this case is a cone-shaped piece of brass, which makes a seat in a depression provided for it. The valve V, and the seat are formed as desired and then ground into contact with emery dust or other abrasive material, to assure a perfectly tight joint. When this valve becomes worn and begins to leak, it may be repaired by regrinding, but such work requires the services of a pipe-fitter. The tendency of modern practice is to use valves with the detachable discs, such as that of figure 77, because they are easily repaired.

The valve shown in figure 79, is known as a *gate-valve*. The upper part, including the screw and stem, is the same as the globe style but the valve proper is made in the form of two flat gates A-A. When the valve is closed, as it appears in the drawing, the gates are forced against the seats by the cone-shaped piece B, which acts as a wedge, to tightly close the opening. When the hand-wheel is turned to open the valve, the gates are raised and are taken entirely out of the path of the flowing liquid.

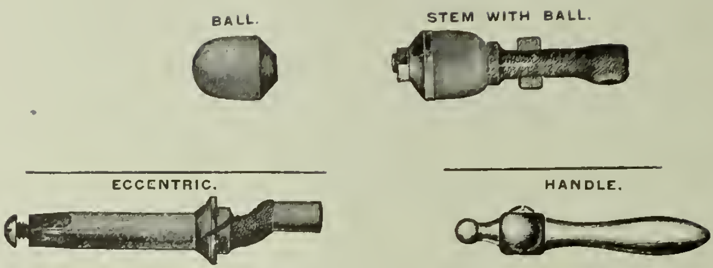


Fig. 72—Repairs for Fuller cocks.

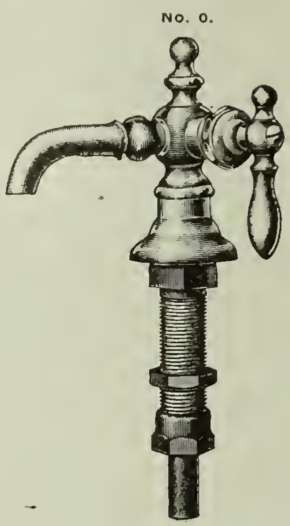


Fig. 73—Fuller basin cock.

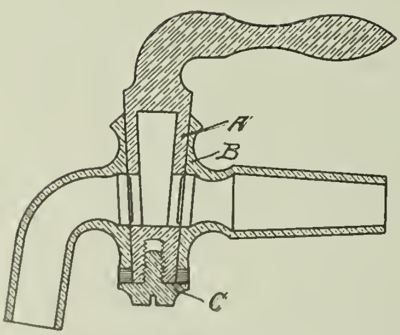


Fig. 70—Cross-section of lever handle, plain bibb.

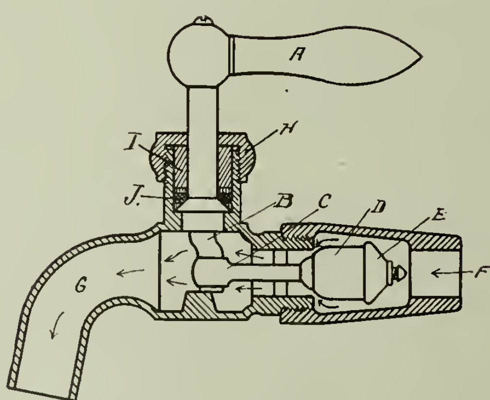


Fig. 71—Plain Fuller bibb for lead pipe.

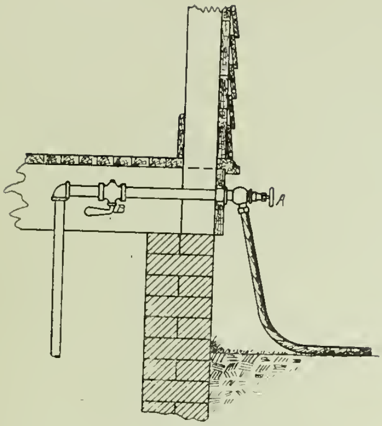


Fig. 75—Sill cock in place attached to the water pipe.

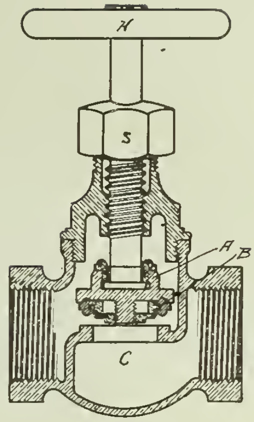


Fig. 77—Cross section of globe valve with detachable valve disc.

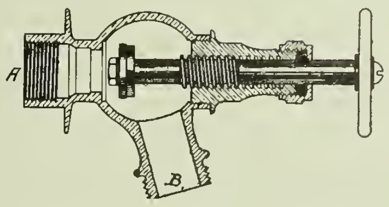


Fig. 76—Cross section of sill cock.

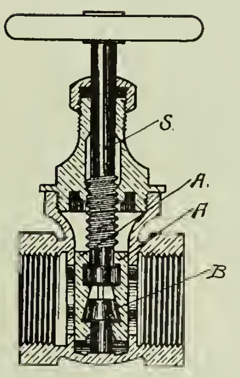


Fig. 79—Cross section of gate valve.

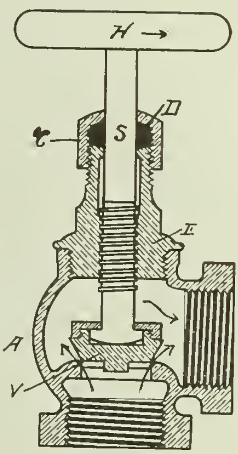


Fig. 78—Cross section of angle globe valve.

Gate-valves are used in places where it is desired to obstruct the flow as little as possible. They are somewhat more expensive than globe-valves but are considered worth the extra expense in service.

The development in modern plumbing has wrought many changes in the styles of household fixtures but none has been so great as that in the kitchen sink. The

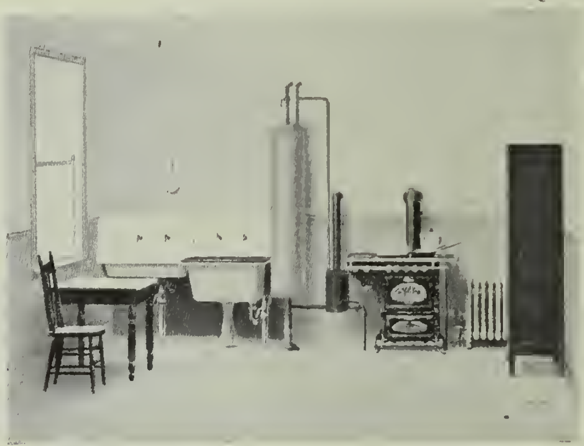


Fig. 80—Model kitchen.

old style, unsanitary, wooden sink has been almost entirely replaced by those made of pressed steel or enameled iron. They are made in every desired size and to suit all purposes. They may be plain or galvanized as occasion may require, or the enameled sink is obtainable at a very slight addition in price. The enameled sink has reached

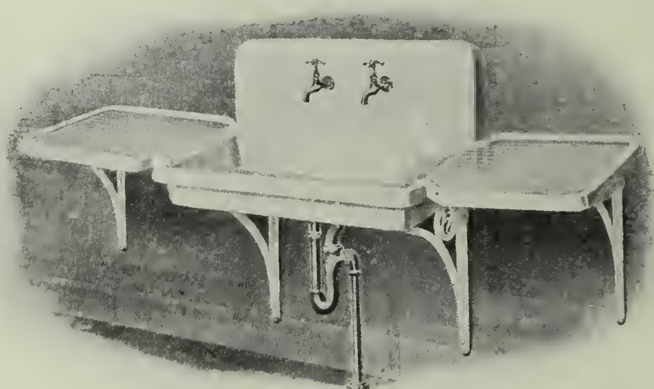


Fig. 81—White enameled-ware sink with drip boards of the same material.

a degree of perfection where its durability is unquestioned, and as a consequence, kitchen furniture is vastly improved at but little advance in cost.

A modern kitchen in which gas is used as fuel is shown in figure 80. Simplicity and neatness of arrangement are the noticeable features. This kitchen is intended to suit the average sized dwelling and contains all necessary plumbing, cooking and heating apparatus. The hot-water boiler is here shown attached to an instantaneous heater. The common kitchen sink is supplemented with a slop sink and covered with a drain board. This simple kitchen may be elaborated to any extent. Figure 81, shows a kitchen sink of white enamel with two enameled drain boards. The drain boards are sometimes covered with perforated rubber mats.

In figure 82 is shown an example of the modern basement laundry. The wash

Fig. 82—Model laundry.

boiler heater is shown on the left. An automatic instantaneous water heater is on the right. The stationary tubs or wash trays occupy the center of the picture. In detail these wash trays appear in figure 83. These are enamel covered ware and are provided with the wash tray bibb cocks described above. This type of plumbing represents the most modern of sanitary arrangements.

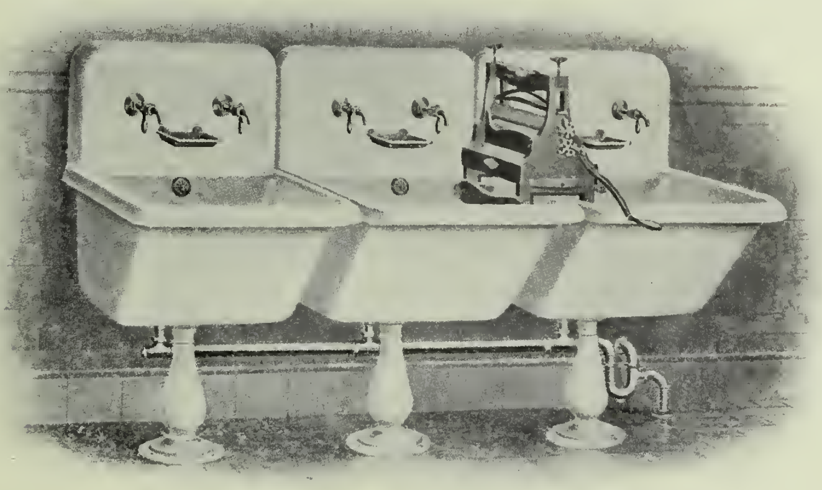


Fig. 83—White enameled-ware wash trays.

THE BATH ROOM

With the present day improvements in plumbing, and the perfection in the manufacture of porcelain and enameled iron, the bath rooms of houses of moderate cost have become places of cleanliness, attractive, relatively free from offending odors and supplied with all necessary sanitary fixtures.

Enameled iron has reached a state of perfection where it rivals porcelain in beauty. The forms of the various bath room pieces have been modeled for convenience in use and grace of form, at the same time the strife of the designer has been to produce articles that not only look well but are convenient and easily kept clean.

Bath rooms need not be expensive in order to be convenient, attractive and useful. The bath room shown in figure 85 is such as is installed in dwellings of moderate price. It possesses every feature necessary to usefulness and comfort. In this room the furnishings are all of enameled iron. The floor is covered with linoleum and the wainscoting with enamel paint.

The addition of a shower, if desired, may be arranged as shown in figure 84. The shower is secured to the wall and a rubber tube, attached to the water cock, completes the necessary apparatus. A rubber or canvas curtain supported to the ring confines the water to the tub.

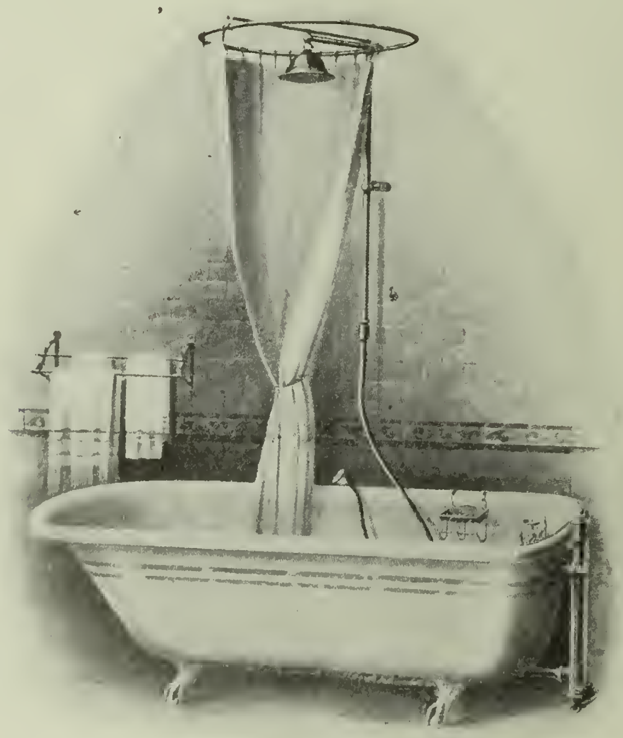


Fig. 84—The shower bath as used with the ordinary bath tub.

In more pretentious bath rooms a foot-bath, such as figure 86, adds to the convenience of the room.

BATH TUBS. Bath tubs are made in sizes that vary in length from 4 to 6 feet. They may be obtained in a variety of forms and of materials to suit all conditions. The least expensive form is made of sheet zinc, enclosed in a wooden frame. For bath tubs that are to receive hard usage and are intended to give the most service for the least expenditure of money, copper lined steel tubs are quite generally used.

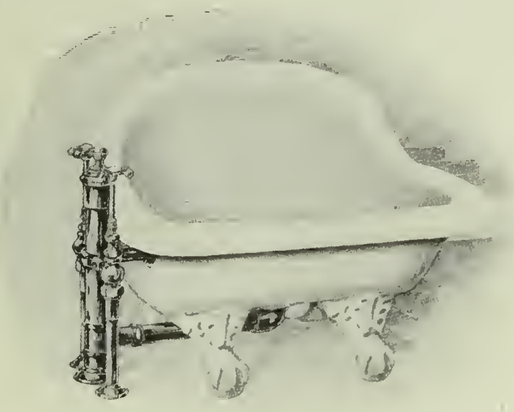


Fig. 86—The seat bath forms a part of the more completely equipped bath room.

Fig. 85—Model bath room for the average dwelling.

They may be obtained from dealers in plumbers' supplies, fitted with the customary water and waste fixtures, in sizes that vary from 4½ to 6 feet in length.

For use in the average dwelling, the bath tub is most commonly of enameled iron. The inside and roll rim is covered with a heavy coat of white enamel that

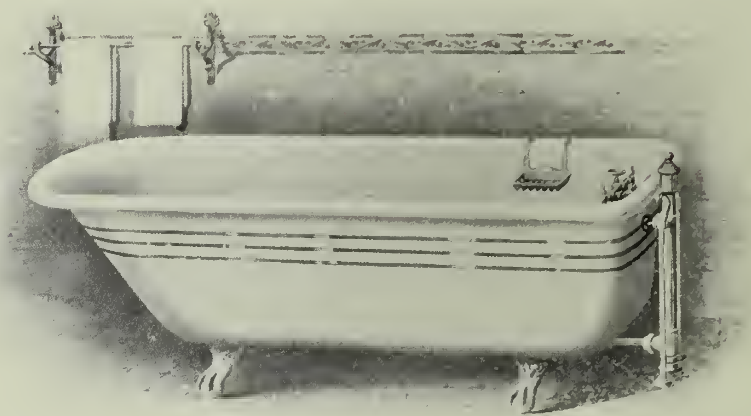


Fig. 87—Enameled iron bath tub.

approximates very closely the more expensive porcelain. Figure 87 shows such a tub in place. As these tubs come from the factory the outside, below the rim, is painted with a coat of brown mineral paint. They may be obtained with the outside finished in zinc white at an additional cost. A common custom is to install the tub as it comes

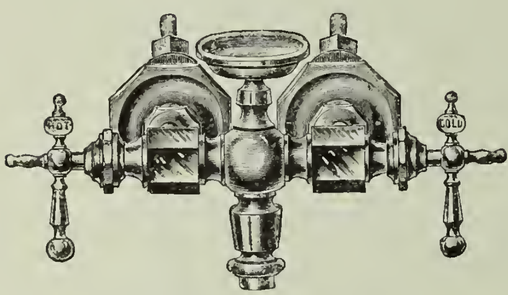


Fig. 88—Double Fuller cock for the bath tub.

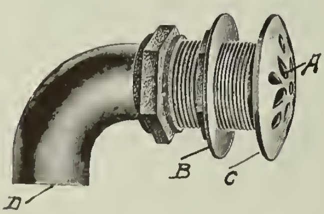


Fig. 89—Details of the bath tub overflow.

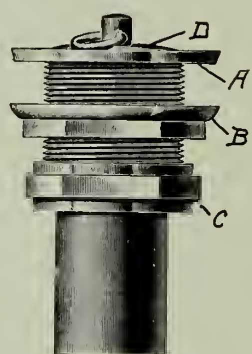


Fig. 89-a—Details of the bath tub drain.

from the factory and afterward paint it with two or more coats of white enamel paint. Finished in this way, it is easy to keep clean, looks well and is just as serviceable as the more expensive tubs.

The fixtures usually provided with the tub are double Fuller or compression cocks for hot and cold water, the overflow and strainer, for the discharge of the water into the sewer in case the tub overflows, and a drain and bath plug.

The double Fuller cock is shown in figure 88. It is made to open and close by the same sort of mechanism as is shown in figure 71, a description of which appears on page 74.

The overflow is shown in detail in figure 89. The part A, appears inside the tub. It is made watertight around the edge C, by a rubber washer that is clamped tight to the surfaces by the nut B. In case of leakage, the overflow may be removed for repair by unscrewing the union attached to the piece D and removing the nut B.

The drain pipe connection is shown in figure 89-a. The plug D, and the flange A, show inside the tub. The flange is made water tight by a rubber washer that the nut B clamps tight to the tub. The part C, is a union which permits the tub to be detached from the drain pipe. Repairs to this joint may be made as in the overflow.

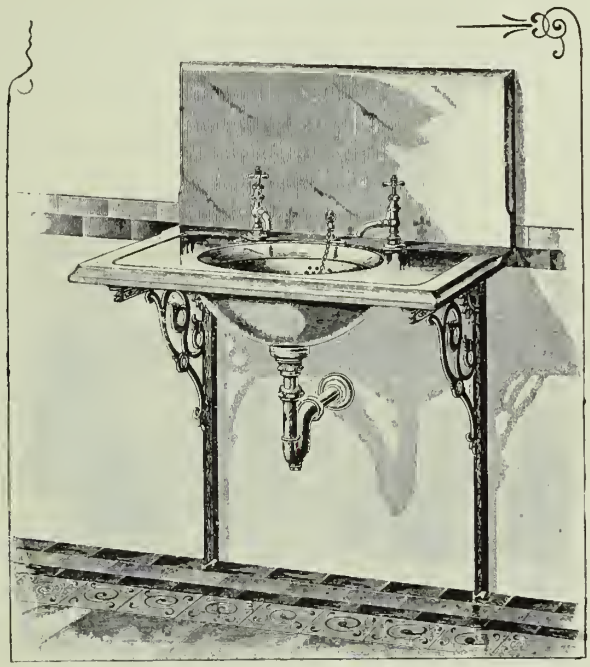


Fig. **90**—Old style form of marble-top wash basin.

Wash Stands and Lavatories. Wash stands for bath rooms are obtainable in many forms, either plain or ornate, to suit every condition and style of architectural finish.

They are made in marble, porcelain and enameled iron, the last being the most commonly used. They are made to suit the part of the room to be occupied, whether that is against a wall, a corner, or to stand on a pedestal on the floor. Those intended to fasten to the wall may be supported by brackets or suspended at the back from pieces secured in the wall.

In figures 90 and 91 are shown samples of marble finished wash basins. In former years basins of this type were very much in use, and until the introduction of the modern porcelain and enameled ware, it was the highest type of sanitary plumbing. The water cocks and traps are of the same style and grade as appear on the most modern examples of enameled ware of figures 92, 93 and 94. The water cocks used in figure 90 are of the compression type. All of the others are of the Fuller type. The basin in figure 92 is provided with extra shut-off cocks on the water pipe under the basin. They are added to the plumbing merely as a convenient means of shutting off the water for repair. The wash stand is usually provided with hot and cold water cocks, a waste pipe with its traps and overflow connections.

TRAPS. The waste pipes from the wash basin and bath tub are always provided with some form of trap, to prevent air from entering the room from the sewer, charged with offending odors. Traps are made in many forms, but the purpose of all is to prevent the escape of sewer gas. The plain trap S, shown in figure 95, is that used under the basin in figure 91. It makes a tight joint by means of the nut B and a rubber washer as in the case of other joints of the kind. The parts C and E are unions that permit the pipe or bowl to be removed without disturbing the remainder of the plumbing. From the form of the trap it will be seen that the U shaped part below the dotted line F, will always remain full of water and so prevents the escape of air

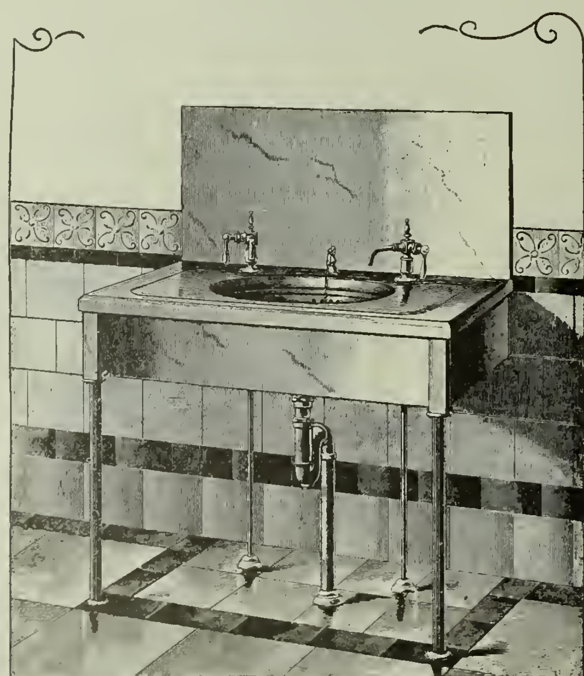


Fig. 91—Old style wash basin with marble finish.

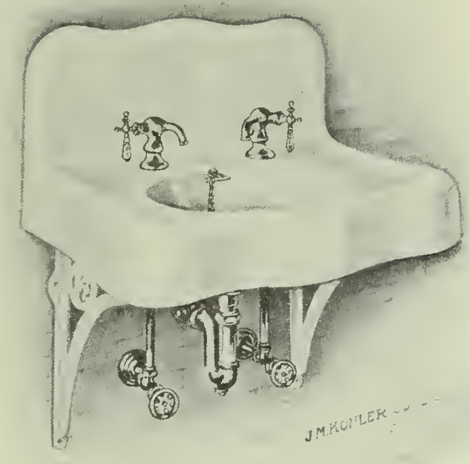


Fig. **92**—Enameled iron wash basin, supported by brackets

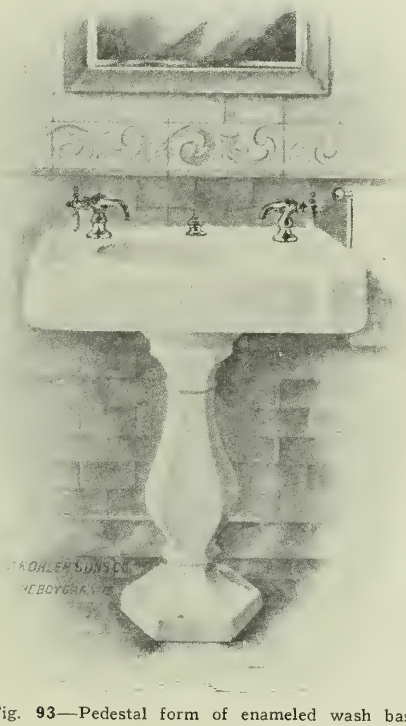


Fig. **93**—Pedestal form of enameled wash basin.

from the sewer. In case the trap becomes stopped the obstruction will likely become lodged in this part of the pipe. To clean the trap the screw plug D is taken out with a pair of pliers and the obstruction removed with a wire.

The traps used in figures 90 and 92 are the same in principle as figure 95 but are made to discharge into a pipe placed in the wall instead of under the floor. The trap in figure 94 is a form known as the bottle-trap that is sometimes used in the more expensive plumbing.

Another style much used with lavatories is the Bower trap shown in figure 96. In this trap the water comes down the pipe B and pushing aside the hollow rubber ball A, enters the space surrounding it and is discharged at C. The ball being light, is held against the end of the pipe by the water and acts as a stopper to prevent evap-

—Corner, enameled iron wash basin, supported by fastenings secured to the wall.

oratoin from taking place. Open traps, such as figure 95, if left standing for a long time, may lose sufficient water by evaporation to destroy the water seal and allow the sewer gas to escape. In the use of the Bower trap such occurrance is much less likely to take place.

Figure 97 is another trap much used on sinks; it is known under the trade name of the Clean Sweep trap. The part C is much larger than in the common trap and the water seal is less likely to be broken. The cleanout is larger and the interior is easy of access in case of stoppage.

The simplest and most commonly used trap in cheap plumbing is that of figure 98. It is a lead pipe bent in the form of an S. It is the same in shape as figure 95 and performs its work as well but does not have the means of detachment shown in the latter. Traps of many other forms are in use but all have the same function to perform and the mechanical make-up is much the same as those described.

The plan of attachment of the various bath room fixtures of the soil pipe must always depend on local conditions. The object is to conduct the waste water to the sewer in such a way as to give the least opportunity for stoppage and to prevent sewer gas from escaping into the house. To accomplish this purpose the pipes and traps are arranged according to a plan proposed by the architect, plumber or other person familiar with the principles of plumbing. Since these pipes are placed in the walls and under the floors, where they are not readily accessible, it is necessary that their arrangement be made with care and that the workmanship be such as to assure correct installation.

In figure 99 is shown a common method of connecting bath room fixtures with the sewer. The drawing shows a bath room with the floor broken away to show the pipe connections with the bath tub, wash basin and closet. The overflow pipes O and V and the drain pipes D and R from the wash basin and bath tub empty into a large lead drum-trap T, set under the floor. This trap takes its name from its shape. It is set in position as dictated by the conditions under which it is used. The nickeled plate P, screwed into the top of the trap comes just above the bath room floor. This plate is easily removed in case of stoppage. It is made airtight by a rubber ring placed under the cover and which makes a joint with the top edge of the drum.

It will be noticed that the waste pipes from the bath tub and wash basin enter the trap near the bottom and discharge at the opposie side near the top. The water will stand in the trap and pipes level with the bottom of the discharge pipe and thus form a seal that prevents the escape of sewer gas. This is a common form of non-siphoning trap. It is non-siphoning because it cannot lose its seal by reason of the siphoning effect of the water as it passes through the waste pipes on its its way to the

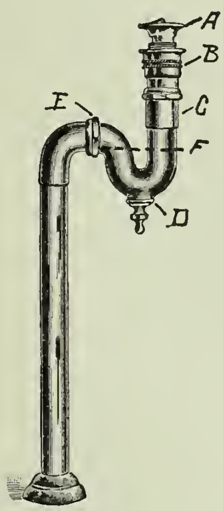


Fig. 95—The S trap with details of construction.

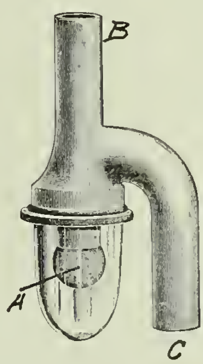


Fig. 96—The Bower trap.

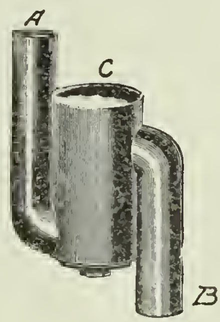


Fig. 97—The clean sweep trap.

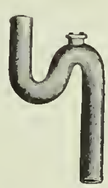


Fig. 98—The S trap

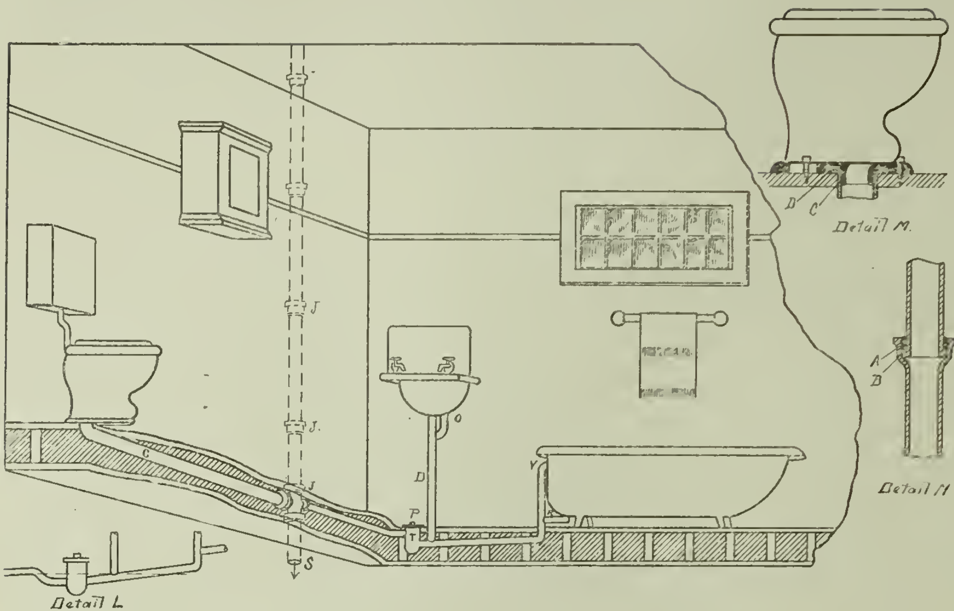


Fig. 99—A method of bath room plumbing using the drain trap.

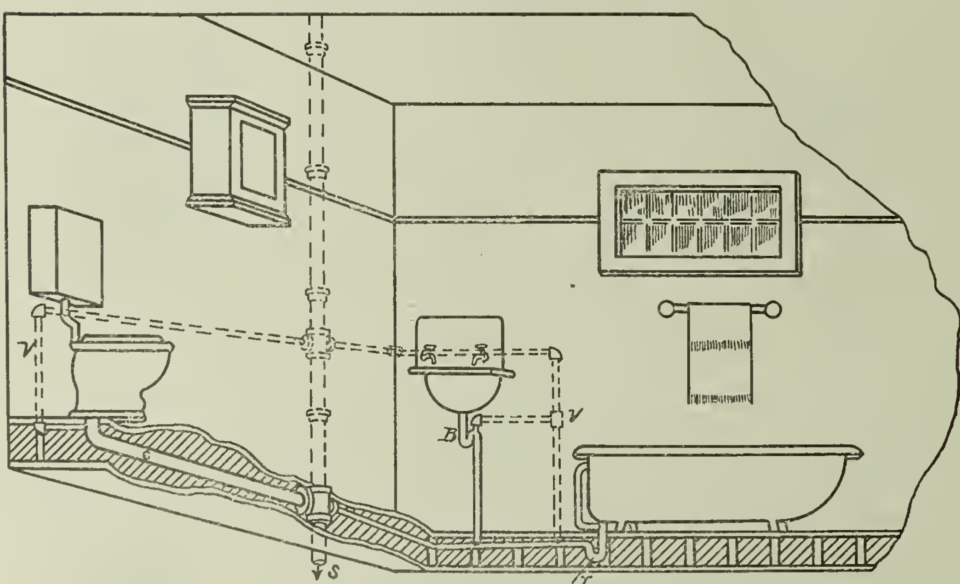


Fig. 100—An example of back-vented plumbing as applied to the bathroom.

sewer. Another form of non-siphoning trap is the clean sweep trap shown in figure 97. Such traps as figures 95 and 98 are siphoning traps, since it is possible, in this form of trap, for the water to be so completely siphoned that not enough remains to form a seal. The small drawing, marked Detail L, is given another method of connecting the same arrangement of fixtures. The waste pipe enters the trap as before but discharges immediately opposite. The level of the water stands in the pipes as indicated by the dotted line.

Back Venting: To prevent the possibility of loss of seal by siphoning and the escape of sewer gas, traps are back-vented to the main stack or to a separate vent stack. The venting is accomplished by joining a pipe to the top of the trap or to some point in its immediate neighborhood, and connecting this with the main stack or the vent stack. The water in a trap so vented will be open to the air from both sides and consequently can never be subject to siphonic action.

In the average sized dwelling where non-siphoning traps are used, back-venting is not necessary, but in large houses and in plumbing where siphon traps are used, vent pipes must be attached to the traps to assure a satisfactory system.

Figure 100 furnishes an example of back-venting, applied to the bath room shown in figure 99. In the former figure the bath tub and wash basin are connected with the waste pipe by siphon traps. A siphon trap may lose its seal in two ways; by self-siphonage or by aspiration caused by the discharge of the water from other fixtures. In the discharge of the siphon trap, such as B, in figure 100, the long leg of the siphon, formed by the discharge pipe, may carry away the water so completely that not enough remains in the trap to form a seal. Again, the discharge of the water from the bath tub through the waste pipe tends to form a vacuum above it and in some cases the seal in B is destroyed by the water being drawn into the vertical pipe. The possibility of either of these occurrances is prevented by back-venting.

In figure 100, a pipe from the main stack is connected with the bend of the trap at B and also to the waste pipe outside the trap at T. A vent is also taken from the drain C, at a point just below the trap in the closet seat. The object of all of the vents is to prevent the tendency of the formation of a vacuum from any cause that will carry away the water seal of the trap and allow sewer gas to enter the house.

The closet seat also contains a trap which will be described later. It connects with soil pipe J, leading to the sewer by a large lead pipe C.

All of the pipes under the floor, leading to the soil pipe, should be of lead. The pipes above the floor are generally of iron or nickel plated brass. All of the connections in the lead pipes are made with *wiped-joints;* that is, the connections are made by wiping hot solder about the joint, in a manner peculiar to this kind of work, in such a way as to solder the pipes together. The joints made in this manner are perfectly and permanently tight. Lead pipes are used under such conditions, because lead is the least affected by corrosion of any of the metals that could be used for such work.

Soil Pipe. The soil pipe of which the waste stack or house drain is composed, is made of cast iron and comes from the factory covered with asphaltum paint. It may be obtained in two grades, the standard and extra heavy. The only difference is in the thickness of the pipe. The former is commonly used in the average dwelling. One end passes through the roof and the other end joins to the vitrified sewer tile under the basement floor. The joints T must be perfectly tight, because a leak in this pipe would allow sewer gas to escape into the house. One end of each section is enlarged sufficiently to receive the small end of the next section. The joints are made with soft lead. The pipes are set in place and a roll of oakum is packed into the bottom of the joint, after which molten lead is poured into the joint, filling it completely. The oakum is used only to keep the lead in the joint until it cools. After the lead has cooled it is packed solidly into the joint with a hammer and calking tool. The calking is necessary because the lead shrinks on cooling and makes a joint that is not tight. Well calked joints of this kind are airtight and permanent. Detail N (figure 99), shows the arrangement of the parts of the joint as indicated at J. The blackened portion represents the lead as it appears in the joint.

Detail M, (figure 99), shows the methods of attaching the closet seat to the lead waste pipe C. The end of the lead pipe is flanged at the level of the floor, as shown at C in the detail drawing. The depression D, around the connection is then filled with glazier's putty and the seat is forced down tightly in place and fastened with lag screws.

The pipe C, from the closet, and that from the trap T, being of lead, a special joint is necessary in connecting them with the soil pipe, because a wiped joint cannot be made with cast iron. To make such a connection the end of the lead pipe is "wiped" onto a brass thimble, heavy enough to allow it to be joined to the soil pipe by a calked lead joint. The brass thimble is then joined to the cast iron pipe by a calked lead joint.

WATER CLOSETS. Water closets are made in a great number of styles to suit the architectural surroundings and the various conditions under which they are to be used. Many forms of water closets are manufactured to conform to special conditions, but those commonly used in the bath rooms of dwellings are of three general types The mechanical construction of each is shown in the following drawings; figures 101, 102 and 103, showing respectively in cross-section, the principle of operation of the *washout* closet, the *washdown* closet and the *siphon-jet* closet.

WASHOUT CLOSETS. This type of closet has in the past been used to a very great extent. It does not perform the work it has to do, so perfectly as the others,

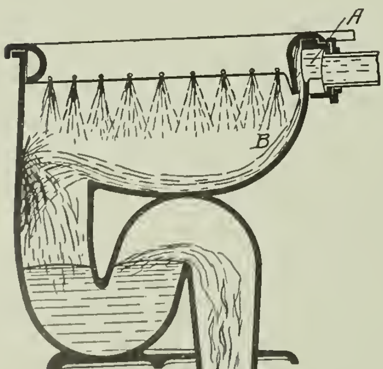


Fig. 101—The wash-out closet.

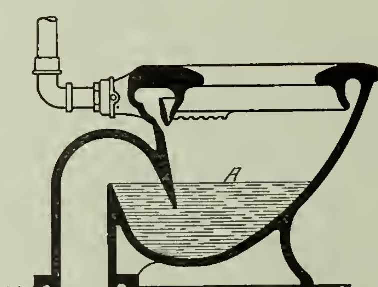


Fig. 102—The wash-down closet.

because the shallowness of the water in the bowl allows it to give off odors, and because it is difficult to keep clean. The action of the closet is as follows: when the closet is flushed the water enters the rim at A, and the greater portion of it is washed downward at B to dislodge the contents of the bowl. A lighter flush is sent through the openings in the side, which serves to wash the entire serface. The direction of discharge is forward, where it dashes against the front of the bowl and then falls into the trap. The only force received to carry the water to the trap is from falling through the distance from the point where it strikes the front. The flushing action is obtained from the use of a large volume of water. As the discharged matter is dashed against the front of the bowl, the flushing action of the water is not sufficient to remove all the stains, the result is an accumulation of filth. This part of the bowl is out of sight; hence, it is seldom kept clean. The name washout comes from the action of the water to wash out the contents of the bowl.

WASHDOWN CLOSETS. As shown in figure 102, the action of this closet is to wash the contents of the bowl directly down the soil pipe. The depth of the water at A, is much greater than at the corresponding point in the washout closets, as a con-

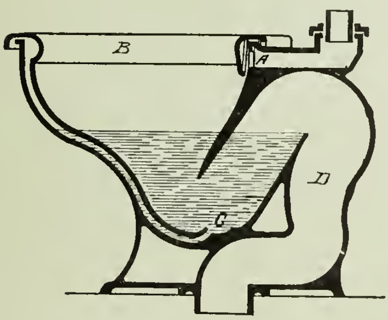


Fig. 103—The siphon-jet closet.

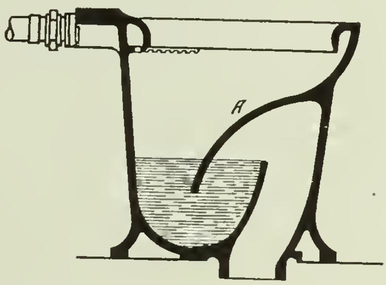


Fig. 104—A poor design of wash-down closet.

sequence faecal matter is almost submerged. The main objection to this closet is that it is noisy. Figure 104 shows another form of washdown closets. This closet is open to objection because of faulty design; the part A is difficult to keep clean because of its shape.

SIPHON-JET CLOSET. What is considered by many to be the most satisfactory closet yet designed, is that of the siphon-jet type shown in figure 103. The flushing action of this closet is entirely different from that of the others described. The flushing water enters at A and fills the rim B. Part of the water washes the sides of the bowl, while the remainder flows through the jet C, and is discharged directly into the outlet. The ejected water enters the outlet D, which, as soon as it fills, acts as a siphon to draw the water into the soil pipe. This closet is most positive in its action, since the discharge is made by the siphon and also receives the additional momentum due to the water flowing through the jet. Its action is attended with but little noise.

FLUSH TANKS. The water closet depends for its action on one of two general types of flush tanks; the high and the low forms. The tank is automatically filled with water and when wanted, a large volume of water is suddenly discharged into the

Fig. 105—Siphon-jet closet with the high flush tank.

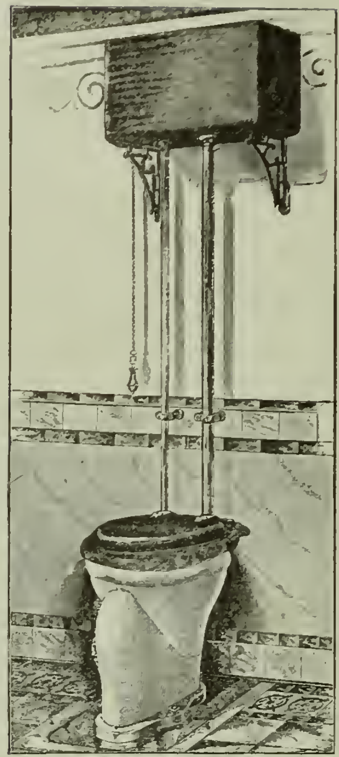


Fig. 106—The wash-down closet with the high flush tank.

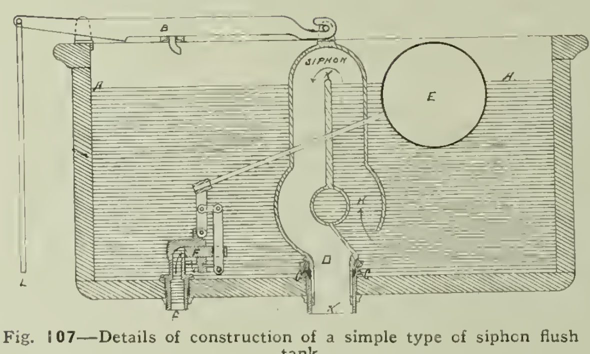


Fig. 107—Details of construction of a simple type of siphon flush tank.

sewer, carrying with it the contents of the seat. The tank again fills and is ready for use when required.

As illustrations of high flush tanks, those shown in figures 105 and 106 furnish examples of a simple and efficient form. The details of the mechanism of this type of tank are shown in figure 107. The pipe from the water supply is attached at G, to the automatic valve F, which keeps the pipe filled with water. The piece F of the valve is held against the opening by the pressure exerted through the float E. The float is a hollow copper ball. As the ball is lifted it exerts a pressure in proportion to the amount it is submerged. When the water reaches the level A - A, the valve is tightly closed. As the water is discharged from the tank the ball follows the level of the water and opens the valve, allowing the water to enter and again fill the tank.

The siphon is made of cast-iron, and in the figure is shown cut through the center. The lower end fits loosely in the piece K, and makes a watertight joint around its outer edge, by resting on a rubber ring C-C. The right hand side of the siphon is open at H, and when the tank is full, the level of the water is at A - A, which is almost at the top of the division-plate. To discharge the tank, the chain L, attached to the lever B, is pulled down; this action raises the syphon from its seat. As soon as the siphon is lifted, the water rushes through the opening around C-C, into the pipe K; this causes a partial vacuum to form in D, and the water is lifted over the division plate K, and flows out at D, forming the siphon. As soon as the siphonic action begins the siphon may be dropped back on the seat and the water will continue to discharge until the tank is empty.

Low Down Flush Tank. The low-down flush tank for water closets has met with so much favor that it has to a great extent displaced the high tank. The reason for this is because of its advantages over the other style. The low tank is more accessible, more easily kept clean, and better adapted to low ceilings. It is used successfully as a siphon tank, but other forms are in use with satisfactory results.

Figure 108 gives a perspective view of one style of this type of tank attached to a siphon-jet closet. Figures 109 and 110 give the details of the construction of two forms of this type of tank; both of which have given efficient service. The drawing shows the tanks with the front broken away to give a view of the working parts. The water enters the tank and is discharged at the points indicated. The float and supply valve works exactly as described in the high tank. The drawing in figure 109 shows the tank in the act of discharging. The discharge valve is raised as shown at E. When the water is completely discharged, the float occupies the position shown dotted. When the float reaches this dotted positoin, its weight pulls down the piece A. This releases the lever B, and the attached stopper E, which falls and closes the discharge orifice. While the tank is filling with water, a stream flows through the small pipe D, to replenish the water in the closet that has been discharged in siphoning. When the tank is full of water, the pieces A, and B, occupy the positions shown dotted. To discharge the tank the *trip* is pushed down. This action raises the lever to the position B, and with it the attached stopper E. The piece C, falls and the opposite end A, holds B, suspended until the tank is completely discharged.

The action of the tank shown in figure 110 is the same as the others except that of the discharge mechanism. In the drawing, the tank is full of water ready to be discharged when required. A hollow rubber ball E, serves as a stopper for the discharge

Fig. 108—Siphon-jet closet with low-down flush tank.

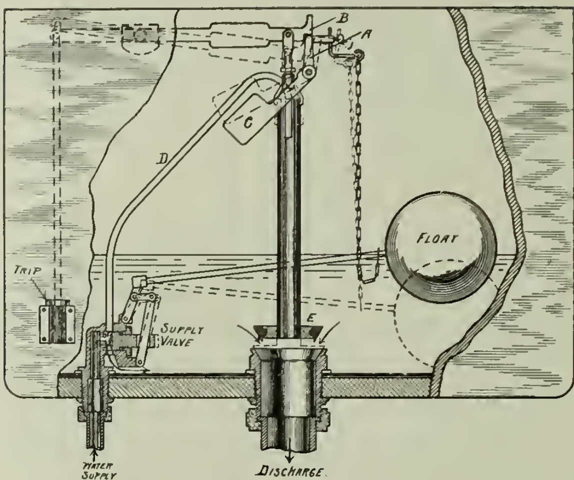


Fig. 109—Details of construction of low-down flush tank.

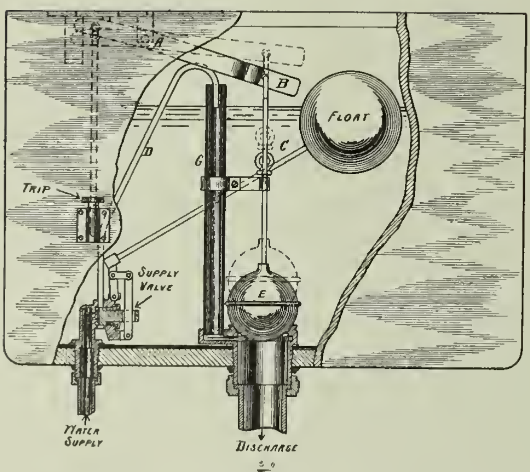
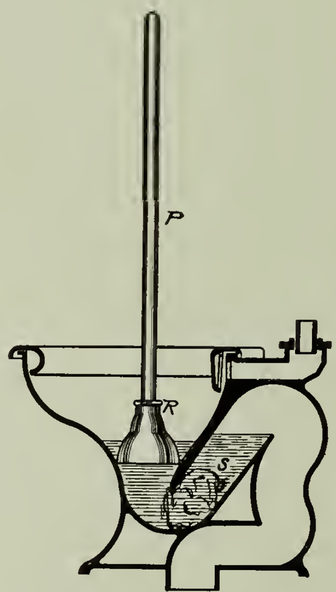


Fig. 110—Details of construction of the float-valve, low-down flush tank.



g. 111—Method of using the Plumbers' Friend, in removing obstructions.

pipe. The ball is kept in place, when the tank is filling, by the pressure of the water above it. The discharge is started by pressing down the trip on the front of the tank. This raises the ball from its seat, and being lighter than water, it floats, thus leaving the discharge pipe open until the tank is empty, when the ball is again back on its seat. As the tank fills the pressure of the water above prevents the ball from again floating, until lifted from its seat. The supply valve and refilling pipe D, is the same in action as in the other tank.

OPENING STOPPED PIPES. It occasionally happens that pipes leading from the various toilet fixtures become stopped because of accumulations or by articles that accidentally pass the entrance. In case the pipe has a trap connection the soppage is most likely to occur at that point. Usually the obstruction may be removed by detaching the screw plug of the trap and removing the accumulation with a wire.

Closet seats furnish an inviting receptacle for waste material of almost every kind. Stoppages are not uncommon and are generally found in the trap. One method of removing obstruction is by use of the plumbers' friend. This device is shown at P, R, in figure 111. It consists of a wooden handle P, attached to a cup-shaped rubber piece R.

The plumbers' friend is shown in the figure, placed to remove an obstruction S, that is lodged in the trap. A sudden downward thrust causes the rubber cap R, to entirely fill the closet outlet and the resulting pressure to the water is generally sufficient to force the obstruction through the trap to the soil pipe.

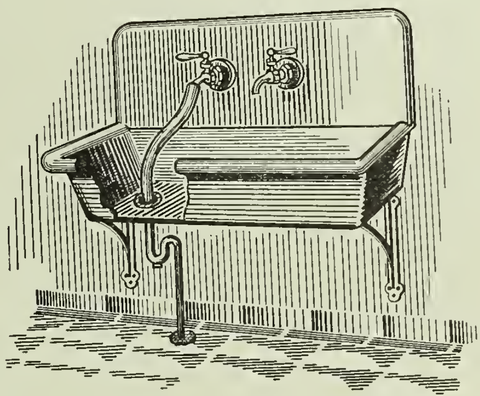


Fig. 112—Method of removing obstructions from a stopped drain-pipe.

The kitchen sink is another place that affords opportunity for accumulation that stops the waste pipe. Accumulation of grease in the trap is a common cause of trouble. This may be remedied to some extent by the use of potash or caustic soda. When the pipe is stopped and the trouble cannot be reached from the trap, a common method of removing the stoppage is that suggested in figure 112. A piece of heavy rubber tubing is forced over the water tap and the other end tightly wedged into the drain pipe; the water is then turned on and generally the pressure is sufficient to force the accumulation down the pipe.

RANGE BOILERS

The hot water supply to the household is of so much importance, that the installation of the range boiler should be made with great care, and an understanding of the principle on which it works should be fully appreciated by all who have to do with its management. The ability of the boiler to supply the demands put upon it, depends in a great measure on its size and the arrangement of its parts, but proper management is necessary to assure a supply of hot water when required.

Range boilers are used for storing hot water heated by the *water-back* or other water heater, during a period when water is not drawn. It serves as a reserve supply where the heater is not of sufficient size to heat water as fast as is demanded.

As commonly used, range boilers are galvanized steel tanks made expressly for household use. They are standard in form and may be bought of any dealer in plumbing or household supplies. In capacity they range from 20 to 200 gallons and are made for either high or low pressure service. They are said to be tested at the factory to a pressure of 200 pounds to the square inch and are rated to stand a working pressure of 150 pounds. Range boilers are galvanized after they are made and coated both inside and out. The coating of zinc received in the galvanizing process helps to make their seams tight and at the same time renders the surface free from rust.

There is no definite means of determining the size of tank to be used in any given case, because of the varying demands of a household but a common practice is to allow five gallons in capacity to each person the house is able to accommodate.

THE WATER BACK: The most common method of heating water for the range-boiler is by use of the *water-back* or *water-front* of the kitchen range. The *water-back* is a hollow cast-iron piece that is made to take the place of the back fire-box lining of the range. In some ranges the heater occupies the front of the fire-box instead of the back, in which case the heater becomes the *water-front.*

The arrangement of pipes, connecting the source of water-supply with the boiler is such, that cold water is constantly supplied to the tank as the hot water is drawn. If no water is drawn from the tank, it will continue to circulate through the tank and heater, the water becoming constantly hotter.

The connecing pipes are usually of iron but sometimes pipes of copper or brass are used. The joints should be reamed to remove the burr that is formed in cutting. The angles should be 45 degree bends or better still 90 degree bends in connecting the heater with the tank so as to cut down the amount of friction as much as possible.

In Figure 113, is shown a standard range-boiler connected to the range. The water is brought into the top of the tank through the pipe a-a, and passing through it enters the water-back by means of the pipe b. After passing through the water-back the water again enters the tank through the pipes c, and d, as indicated by the arrow. The *flow-pipe* (carrying the out-going water) from the water-back may be connected with the tank at e, as shown dotted or in some cases the connections are made at both places. The velocity of circulation depends on the vertical height of the column of hot water and the greater height will therefore improve the circulation and thus

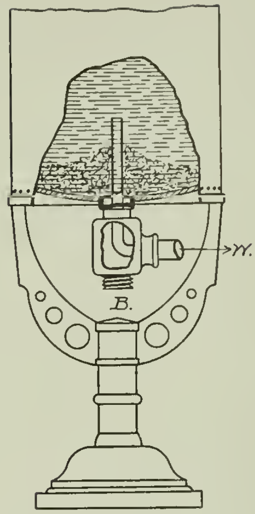


Fig. 114—Blow-off for removing sediment.

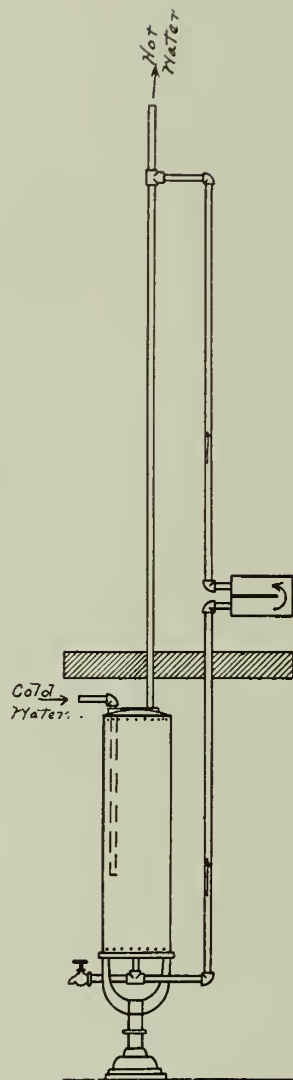


Fig. 115—Method of connecting the range boiler when placed on the floor below the heater.

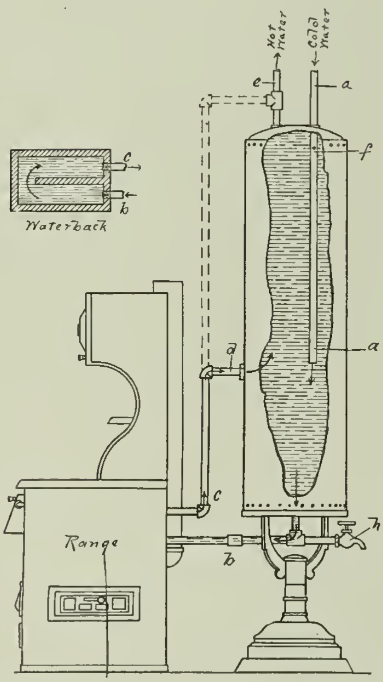


Fig. 113—A common method of connecting the range boiler to the water-back.

increase the efficiency of the heater. The circulation of the water through the tank and heater is produced by its change in weight as the water is heated. As the hot water comes from the water-back it rises in the pipe because it is lighter in weight than the cooler water of the tank. In the case of the pipe shown dotted in Figure 113; the longer vertical rise will give a greater upward velocity of the hot water and consequently a better circulation through the whole circuit.

The construction of the water-back is shown in the small drawing. The connections are made at b, and c, as before. A division plate in the water-back causes the water flowing in at b, to follow the length of the heater at the bottom and return at the top as indicated by the arrow, when it is discharged at C.

The hottest water is always at the top of the tank and the temperature grades uniformly from the hottest at the top to the coolest at the bottom. The reason for extending the pipe a, so far down into the tank is that the cold water may not mingle with the hot water and reduce its temperature on entering the tank. Near the top of the pipe a, is a small hole f, that is intended to prevent the water from being siphoned from the tank in case a vacuum is formed in the cold water pipe. In this arrangement the water enters and leaves at the top of the tank. In case the supply is shut off at any time the tank is left almost full of water, because the siphoning effect cannot extend below the small hole f. Accidents due to the explosion of hot-water backs are not at all rare and it should be borne in mind that there is danger of excessive pressure being formed should the pipes b, and c, become stopped. Under normal conditions the pressure generated by the heated water is relieved by the water in the tank being forced back into the supply pipe. The pressure in the tank therefore cannot become greater than that of the source of supply, but if b, and c, should become stopped with the water-back full of water a dangerous pressure might result. The greatest danger from this cause is that of freezing. It frequently happens that houses are closed during cold weather and the water-back is left undrained. The water freezes and when a fire is started in the range, the ice in the water-back is the first to melt. In a short time steam will be generated that will soon produce a sufficient pressure to burst the water-back. This has happened many times with disastrous results. Such dangers may be avoided by the exercise of a reasonable amount of care in the management of the range. To drain the water-back, the water is first shut off at the point where the supply pipe enters the house. The water in the range-boiler is then drawn off by means of the cock h.

Blow-off Cock: When a considerable amount of sediment is carried in the water the range-boiler acts as a settling tank and the deposit accumulated at the bottom will in time amount to a source of trouble. The accumulation is shown in Figure 114. The part W, which connects with B, is sometimes provided with a blow-off cock that will admit of a discharge of the sediment. More commonly the piping is arranged as shown in Figure 113, when sediment is removed by occasionally drawing water from the cock h.

It is sometimes desired to place the range boiler on a different floor, either above or below the range. While such arrangements are entirely possible the circulation of the water is not so good as that described above. The weight of the two columns of water in the connecting pipes are so nearly balanced that good circulation is not always possible. In Figure 115 the connections are shown, where the tank is located in the basement. In connecting the water-back to the tank under such conditions the piping is relatively the same as is shown in the dotted connections of Figure 113, but the connections are longer. The circulating pipe comes from the bottom of the tank and leads to the bottom of the water-back. The flow pipe from the top of the water-back is extended up to a distance equal or greater than the distance from the water-back to the bottom of the tank. The hot water is taken from the top of the flow pipe at any place above the tank.

DOUBLE HEATER CONNECTIONS: Two heaters are sometimes connected to one range boiler, each circuit being independent of the other. Under such conditions one or both heaters may be used. When the tank is connected as shown in Figure 116 the pipe a, from the bottom of the tank, branches and leads to b and b', at the

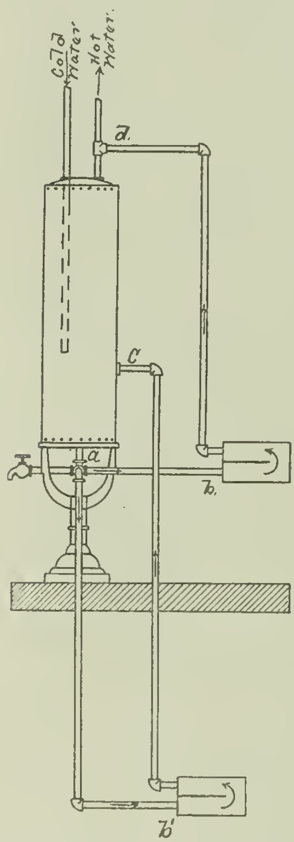


Fig. 116—Double connections for the range boiler where a heater is placed in the basement for occasional use.

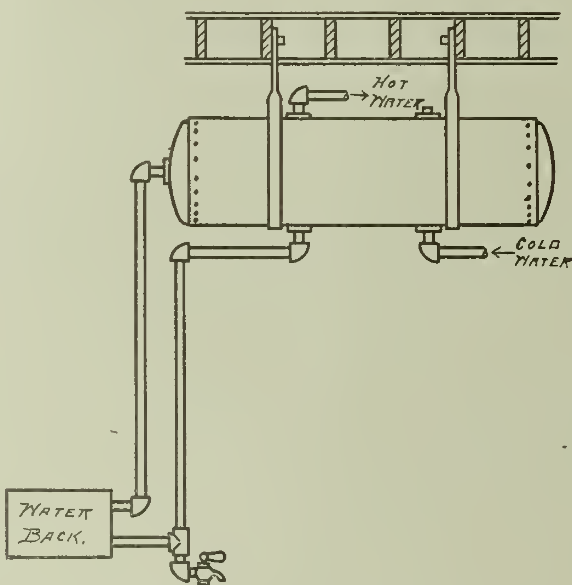


Fig. 118—Horizontal range-boiler, suspended from the ceiling.

bottom of each of the heaters. The flow pipes from the top of the heaters enter the tank at separate places, the lower heater sending its water into the side of the tank at c, and the upper heater flowing into the pipe d, at the top of the tank. It would be perfectly possible to reverse the connections, for the flow pipes in the arrangement of Figure 116 and attain the same results. In such combinations the heaters are sometimes piped tandem, the water flowing through each of the heaters in turn. This however, is not a good method to pursue since in case only one of the heaters is used the second serves to cool the water.

Horizontal Range Boilers: It occasionally happens that in a small kitchen there is no convenient floor space for the range-boiler and it becomes necessary to suspend it from the ceiling. It is perfectly possible to station the ordinary range-boiler in such a position and have it work fairly well but from the location of the cold-water inlet, only that part of the range-boiler above the cold water pipe is actually used for storage. The water in the lower half constantly mixes with the entering cold water before it is heated by passing through the water-back. When hot water is drawn from the top of the range-boiler, cold water enters by the cold-water pipe and reduces the temperature of most of the lower half. Figure 117 illustrates such an arrangement. In this case the pipes connected with the water-back are those that correspond to the circulating pipes a, and e, in Figure 113.

Suppose the range-boiler is full of water, and that it is being heated. The lower pipe at the left-hand end is conducting the water to the water-back and it is being returned to the range-boiler by the upper pipe at the same end. When the hot water is drawn from the top of the range-boiler by the *hot-water* pipe, the entering cold water mixes with hot water in most of the lower half of the range boiler before it has been heated by passing through the water-back and so reduces the temperature of most of the lower half of the tank.

A much better tank for the purpose is that indicated in Figure 118. This is a tank made particularly for such a location. The cold water enters at the bottom of the tank and also leaves the bottom on its way to the water-back. Circulation takes place through the water-back as before but when hot water is drawn from the top of the tank, the entering cold water at the bottom mixes with only that at the lower part of the tank and so cools but a small amount of the hot water in storage. Hot-water tanks of this kind are tapped for pipe connections in two places on both the top and bottom sides and also at the ends as shown in the drawing.

Tank Heaters: When the demand for hot water is sufficient to warrant a separate hot water heater the apparatus similar to Figure 119 is used. With such a heater, the condition of over-heated water—to be described later—may be almost entirely avoided. In this case the connections are arranged similarly to those of the range-boiler but a separate furnace takes the place of the water-back. The heater is simply a small furnace made expressly for heating water. Connected with the discharge pipe p, is a draft regulating valve which controls the drafts of the heater. The draft-regulator is set to so control the furnace that water at the desired temperature will always be in the tank. The mechanism of this regulator is the same as the draft-regulator described under Hot-Water Heating Plants.

Overheated Water: Under ordinary conditions the water contained in the range-boiler is below the atmospheric boiling point (212 degrees Fahrenheit) but at times when a hot fire is kept up in the range for a considerable period, the temperature will rise to a degree much above that amount. The temperature to which the water will rise will depend on the pressure of the water supply. As an example—suppose the gauge pressure of the water supply is 25 pounds. The temperature corresponding to that pressure is 258 degrees F. The temperature of the water in the tank will rise to that amount but not further because any additional temperature will produce a higher pressure, but a higher pressure would be greater than the pressure of the water supply and hence will back the water into the supply pipe. This condition of things then, acts as a safety valve to the tank to prevent excessive pressures.

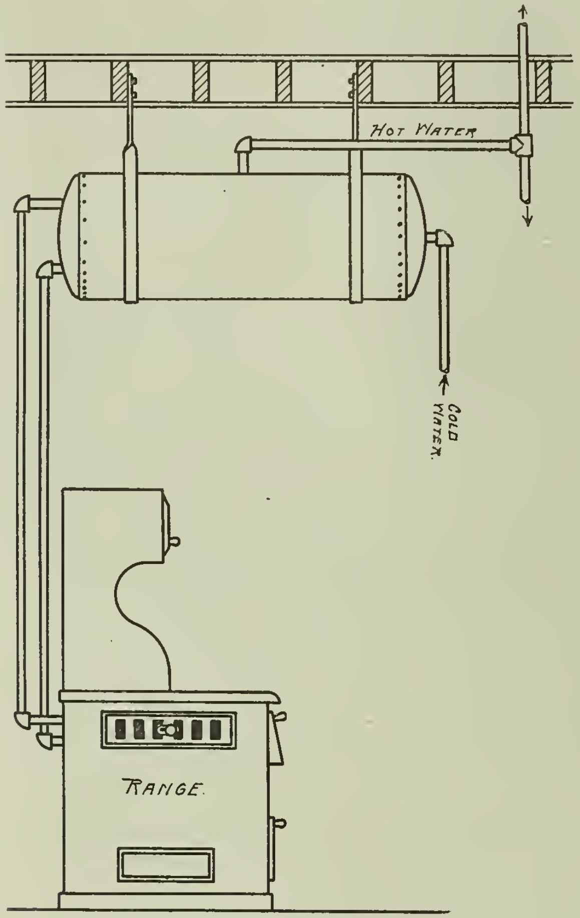


Fig. 117—Method of connecting the vertical range-boiler in a horizontal position.

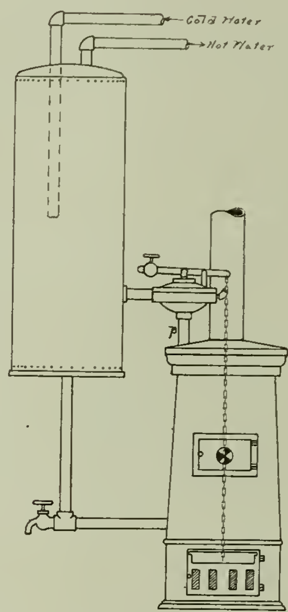


Fig. 119—Independent hot-water heater with temperature regulating valve.

When the water at a high temperature is drawn from the tap a considerable part of it will instantly vaporize, because of the reduced pressure. If water at a pressure of 25 pounds is drawn from the faucet, the temperature, 258 degrees F., is sufficient to send all of the water instantly into steam. This high temperature will scald at the slightest touch. The water drawn from the faucet will continue to vaporize as it comes into the air until the water in the tank is cooled by the incoming cold water. The only means of relieving the overheated condition is to open the faucet a slight amount and allow a portion of the heated water to be drawn off.

FURNACE HOT WATER HEATERS: It is sometimes more convenient to use the furnace as a means of heating water than the kitchen range. Such an arrange-

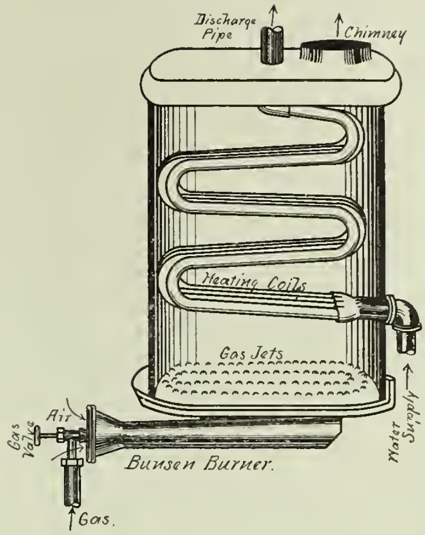


Fig. 121—Instantaneous water heater.

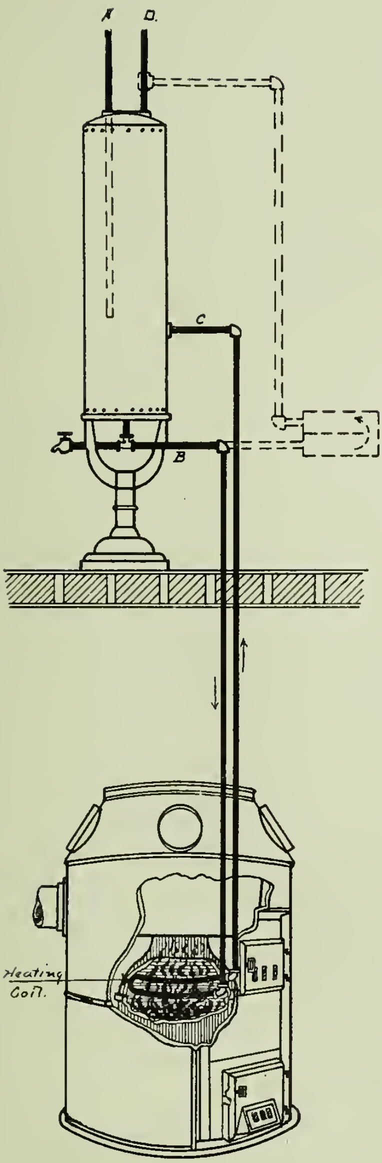


Fig. 120—The range boiler connections when a furnace coil is used for hot water heating.

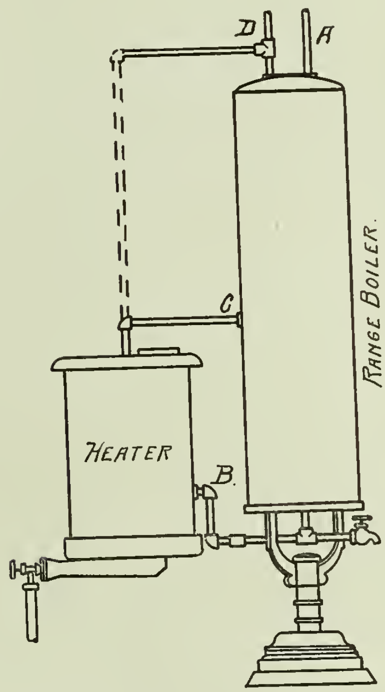


Fig. 122—Instantaneous water heater connected to the range boiler.

ment is shown in Figure 120, where a loop of pipe in the fire-box of the furnace takes the place of the water-back. The arrangement of the pipes in the range boiler are as before, the water entering the tank through the pipe A, circulates through the pipes B and C, receiving its heat while passing through the loop in the furnace, in exactly the same way as in the water-back. It would be quite possible to also connect the kitchen range with the tank as shown by the dotted lines indicating the water back. Such an arrangement would virtually be the condition shown in Figure 116, where the two heaters on different floors are connected with the boiler.

INSTANTANEOUS HEATERS: In isolated bath rooms where no constant supply of hot water is available, instantaneous hot water heaters are much used. In many houses where a range fire is used intermittently, particularly during the summer months, a like method is used for the hot water supply. These heaters are made in many forms to suit any condition. Some are very simple, being made of a gas heater, the heat from which is held against a long coil of pipe or a large amount of heating surface in other form, through which the water circulates on its way to the tap. Others are quite elaborate, being made entirely automatic in their action. The Ruud heater, for example, is so constructed that when the hot-water faucet is opened the reduced water pressure starts a gas-heater in contact with a series of pipe coils through which the water circulates. As soon as the water faucet is closed the water pressure automatically closes the gas valve, cutting off the supply of gas. A little gas jet used for igniting the burner is left constantly burning, ready to light the gas whenever hot water is required.

Figure 121 illustrates a simple form of instantaneous heater that is relatively inexpensive and has met with a great deal of favor. A sheet iron casing encloses a sinuous, multiple coil of pipes through which the water passes. The heat furnished by a Bunsen burner of a large number of small jets is evenly distributed over the bottom of the heater. The heating coils are arranged to interrupt the heat passing through the casing and absorb as much as possible. To do good work such a heater must be connected by a pipe to a chimney flue which furnishes a good draught.

Instantaneous water-heaters should not be used in bath-rooms unless the products of combustion from the heater are carried away by a chimney. The combustion of the required amount of gas produces a large volume of carbonic acid gas which if allowed to remain in the room is not only deleterious but may be a positive danger to life. Cases of asphyxiation from this cause are not at all rare.

Figure 122 shows the heater connected with a range-boiler. In this case the heater may be considered as taking the place of the water-back. It may, however, be used as an auxiliary heater. In the picture of the kitchen shown in Figure 80, an instantaneous heater is shown attached to the range-boiler. It is located in this case between the kitchen range and the boiler.